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THE GENERATION
OF
ANIMAL HEAT,
INVESTIGATED.

WITH AN
INTRODUCTION,
IN WHICH IS AN ATTEMPT TO POINT OUT,
AND ASCERTAIN, THE
ELEMENTARY PRINCIPLES,
AND
FUNDAMENTAL LAWS
OF
NATURE;
AND APPLY THEM TO THE EXPLANATION, OF
SOME OF THE MOST INTERESTING OPERATIONS,
AND STRIKING APPEARANCES
OF
CHEMISTRY.

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INTRODUCTION.

THE Cauſe of Animal Heat hath been much enquired after, and differently explain'd, by many Philoſophers, Phyſicians and others, of almoſt every age; but hitherto, it appears to have been never rightly underſtood.

A great number of the Ancients, and not a few of the Moderns, have chiefly attributed it to friction or attrition, principally produced by the motion of the blood; and ſome have added putrefaction &c. But if friction, or motion be the cauſe of animal heat, why cannot an animal juſt killed, be preſerved at the ſame temperature as when alive, by throwing its parts even into more violent motions than when living? But theſe means are totally inſufficient, to keep its heat above that of the ſurrounding medium: therefore, motion, or attrition alone, cannot be the efficient cauſe; neither can putrefaction, for in the moſt putrid ſtate of a dead animal body, the heat is very far below the living temperature.

The generation of heat during life, and its ceſſation when the vital power or principle is loſt, gave riſe to another opinion, * that heat in animals is produced by irritability; but this advances our knowledge, very little indeed.

A Theory upon very different principles, was ſome time ago offer'd by Mr. Crawford, † which at firſt met with a very favourable reception. His principles are, that heat may exiſt in two very different ſtates; one ſimply as a fluid, active, diſengaged, and having a conſtant tendency to diffuſe itſelf equally over all bodies; the quantity or degree of which is particularly evident, by its effects upon the Thermometer: this he calls ſenſible heat; the other where it is fixt, or com-

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* Recherches ſur differens points de Phyſiologie &c. par M. Fabre. page 23.

† Experiments and Obſervations on Animal Heat.

bin'd with different ſubſtances, and in that ſtate producing no ſenſible effect upon the thermometer: this he calls abſolute heat.

He next aſſerts, that the capacity for containing abſolute heat in any body, is diminiſhed by the acquiſition of Phlogiſton, and vice verſa.

He therefore explains the production of animal heat in this manner: The atmoſpheric air contains a great quantity of abſolute heat, but when it is expoſed to the blood in the lungs, which blood contains a quantity of phlogiſton, the air having a ſtronger affinity attracts the phlogiſton, by which union its capacity for containing abſolute heat is diminiſhed, and a quantity of that abſolute heat is depoſited, proportionate to the quantity of phlogiſton imbib'd. Now if this heat became ſenſible, the blood in the left auricle of the heart, would be much hotter than that in the right; but it is not ſo: therefore, this abſolute heat, depoſited by the air now phlogiſticated, muſt be abſorbed by the blood when it parts with phlogiſton. It appears therefore, that the capacity of the air for abſolute heat, is diminiſhed in proportion to the quantity of phlogiſton acquired: and that the capacity of the blood for containing it, is increaſed by the loſs of that phlogiſton, in the ſame proportion, as that of the air is diminiſhed by receiving it.

This arterial blood then, replete with abſolute heat, during its circulation through the various parts of the body, again receives phlogiſton, and conſequently its capacity for abſolute heat muſt again be diminiſhed; therefore, the more phlogiſton it receives, the more abſolute heat is evolved, and by that evolution becomes ſenſible; and thus forms the heat of animals.

But, if the attraction of Phlogiſton, renders the capacity of any body for abſolute heat, proportionately leſs: ought not the abſtraction of that Phlogiſton, to render that capacity for abſolute heat, proportionately greater? If ſo, the very ſubſtances imparting phlogiſton to the blood, will have their capacities for containing abſolute heat, increaſed, in the ſame degree by its abſtraction, as that of the blood is diminiſhed by attracting that phlogiſton; and conſequently, no ſenſible heat will be produced; as was the caſe with the blood and air in the lungs.

Mr. Crawford's theory, depends upon this change in the capacities of different ſubſtances, not being in the *ſame* proportion to the quantity of phlogiſton acquired or loſt; which merely for the ſake of his hypotheſis, he takes the liberty to ſuppoſe *; but as he only ſuppoſes ſo, and as it ſeems more natural, and juſt, to ſuppoſe the contrary, 'till Mr. Crawford ſhall prove his ſuppoſition is a fact, his Theory muſt be unſatisfactory, as being founded upon laws, which are preſerved or overlooked, as beſt may ſuit the author and his hypotheſis.

Some time after Mr. Crawford's, Mr. Scheele's Theory of Heat &c. was publiſhed in Germany, a tranſlation of which appeared in England †.

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* "If therefore, the whole of the abſolute heat, which "is ſeparated from the blood, were abſorbed by thoſe parts "of the ſyſtem from which it receives the phlogiſton, it "would be neceſſary to have recourſe to ſome other cauſe, "to account for the ſenſible heat which is produced in the "circulation." Experiments &c. page 75.

† Chemical Obſervations and Experiments on Air and Fire, by Charles William Scheele &c.

Though Mr. Scheele does not particularly conſider animal heat, or the manner or functions by which it is produced; yet, as heat is the ſame, whether generated by the animal proceſs, or by combuſtion, his opinion muſt not be paſſed over unnoticed.

He ſuppoſes that heat, or Fire is a compound of Phlogiſton and pure Air, and brings a number of experiments and reaſonings to prove it.

But there is one circumſtance, attending many of his experiments, which he overlooks, and which alone is ſufficient to prove, that his Theory is imperfect; for inſtance, If a metal, ſuppoſe Mercury, be expoſed to the action of heat and air, its phlogiſton unites with the pure air, according to his opinion, and eſcapes in the form of heat, or fire; while the Earth of the Mercury remains deprived of phlogiſton, and the atmoſpheric air of its empyreal air; but from whence does this calx acquire its remarkable increaſe of weight?

Again, If this calx be expoſed to the action of heat, in cloſe veſſels, Mr. Scheele ſays, that the calx decompoſes the heat, by uniting with its phlogiſton, and again acquires its metallic luſtre and properties; while the other component part of fire, the empyreal air, becomes diſengaged, and in that ſtate fills the receiver. But the mercury, now revived by regaining its phlogiſton, is lighter than when deprived of it in the form of calx; how is this loſs of weight to be explained upon theſe principles? By parting with phlogiſton during combuſtion, the mercury gains weight; and by regaining phlogiſton, it loſes weight.

Theſe circumſtances are not properly accounted for by Mr. Scheele, neither can they in my opinion conſiſtent with the principles of his theory, which are therefore inſufficient, and conſequently at leaſt imperfect.

The laſt opinion of any celebrity, which I ſhall mention, is that of M. Lavoiſier.* He denies the very exiſtence of phlogiſton, and makes heat, or Fire, a primitive ſubſtance, which he ſuppoſes becomes ſenſible, or active in the following manner.

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* "Dans la ſuite de Mémoires que je viens de communiquer à l' Académie, j'ai paſſé en revue les principaux phénomènes de la Chimie; j'ai inſiſté ſur ceux qui accompagnent la combuſtion, la calcination des métaux, & en général toutes les opérations où il y a abſortion et fixation "d'air.

Pure or vital air, he ſays, is compoſed of the matter of Fire or heat, with the oxyginous principle; when any body therefore, in contact with vital air, is ſo circumſtanced, as to have a ſtronger attraction

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“ d'air. J'ai déduit toutes les explications d'un principe “ ſimple, c'eſt que l'air pure, l'air vital, eſt compoſé d'un “ principe particulier qui lui eſt propre, qui en forme la baſe; “ & qui j'ai nommé principe oxygine, combiné avec la matière du feu & de la chaleur. Ce principe une fois admis, “ les principales difficultiés de la Chimie ont paru s'évanouir “ et ſe diſſiper, & tous les phénomènes ſe ſont expliqués avec “ une étonnante ſimplicitié.

“ Mais ſi tout s'explique en Chimie d'une manière ſatisfaiſante, ſans le ſecours du phlogiſtique, il eſt par cela ſeul “ infiniment probable que ce principe n'exiſte pas; que c'eſt “ un être hypothétique, une ſuppoſition gratuite: & en “ effet, il eſt dans principes, d'une bonne logique, de ne “ point multiplier les êtres ſans néceſſité.” Hiſtoire de L'Académie Royales Sciences. Anné 1783. page 505.

attraction to this oxyginous principle, than the fire hath, with which it is combined: the oxyginous principle unites with the ſubſtance thus expoſed, and the fire or heat is diſengaged, and becomes active and ſenſible.

If a metal be expoſed, to the united action of heat and vital air, or atmoſpheric air in which vital air is contain'd, it attracts the oxyginous principle, and the matter of heat is ſet at liberty; and this addition of the oxyginous principle to the metal, gives it the increaſe of weight, and renders it a calx. Again, If a metallic calx, of mercury for inſtance, which is compoſed of mercury and the oxyginous principle, be expoſed to a ſufficient degree of heat in cloſe veſſels; the fire unites with the oxyginous baſe, and forms vital air; while the mercury thus deprived of it, is revived, and left in its original form and weight.

The acquiſition therefore of phlogiſton, with other Chemiſts, is nothing elſe than the abſtraction of this oxyginous principle with M. Lavoiſier; and he points out no other mode of its ſeparation from other bodies, than by its uniting with matter of fire, and forming vital air. But how are theſe principles to be applied, to explain the following chemical facts?

The Calx of Silver, according to M. Lavoiſier, is a combination of ſilver with the oxyginous principle; now if this calx be expoſed to the Solar light, the ſilver is revived, and the oxyginous principle is ſeparated; not by combining with heat, becauſe if the ſame calx be expoſed to an equal, or greater degree of heat, without light, the ſilver is not revived. M. Lavoiſier muſt therefore explain, why this oxyginous principle, ſeparates from the ſilver to combine with light; what that combination produces; and why it would not combine with the matter of heat, which ſeems to be the moſt common form of its ſeparation, from the metal with which it was combined. Again, from analogy, I ſhould ſuppoſe, when ſilver is revived from its calx, by the action of light, that vital air is produced; If ſo, how does the union of Light with the Oxyginous Principle, form Vital Air?

What makes me ſuppoſe that pure, or vital air, is produced, during the revival of ſilver, by expoſing its calx to the light, is, the production of vital air when mercury is revived by heat; and from ſuppoſing that light and heat are compoſed of the ſame principles, differently combined, or in different proportions, as will be mentioned hereafter; and conſequently if ſo, that pure nitrous acid, becoming coloured by expoſure to light, muſt yield pure or vital air alſo.

To ſatisfy myſelf whether this conjecture was well founded or not, I made the following experiment.

I kept a phial, half full of pure dephlogiſticated nitrous acid, twelve hours in the dark; when introducing a ſmall lighted taper, it was inſtantly extinguiſhed. I then expoſed the ſame acid to the light, for an equal ſpace of time; and upon introducing the lighted taper, it burnt with a bright, enlarged flame, for a conſiderable time. I again repeated the experiment, and again had the ſame reſults; the acid becoming coloured, and allowing a taper to burn in the phial, after expoſure to the light; but remaining perfectly dephlogiſticated, and immediately extinguiſhing the flame, when kept in the dark. I then tried if heat alone would make any alteration, but conſtantly found, that without light, the taper was always immediately extinguiſhed, let the degree of heat, to which the acid was expoſed, be what it might.

If then the nitrous acid gives out pure air, by being expoſed to the light: it ſeems natural to conclude, that ſilver, when revived from its calx by a ſimilar expoſure, gives out pure air alſo; but this I have not had an opportunity of examining.

How is this laſt fact to be explained upon M. Lavoiſier's principles? He will ſay, that the nitrous acid, parts with its oxyginous principle, and becomes coloured in conſequence; and that the vital air, is produced by the union of this oxyginous baſe, with ——— what? ——— not with the matter of fire, becauſe it refuſed to unite with heat, but ſtill adhered to the acid; —— not with light, becauſe the compound, vital air, according to M. Lavoiſier, is the oxyginous principle with the matter of heat, or fire. The only thing to be ſaid on the ſubject is, that Monſ. Lavoiſier muſt explain the matter himſelf; and 'till he does it ſatisfactorily, I ſhall ſuppoſe his principles are defective, and his ſyſtem erroneous.

I have juſt mentioned theſe Theories, as being the moſt popular; and have pointed out a difficulty attending each of them, which renders the veracity, or ſufficiency of their principles, at leaſt ſuſpicious. But the moſt ready way to prove their fallacy, or inſufficiency, is to *give*, and *ſupport* my own opinion upon the ſubject, which is conſiderably, and fundamentally different from all of them; conſequently, if my own principles prove to be true, theſe as differing from them, muſt be erroneous.

I mean not here to enter into a full explanation, and account of the principles alluded to; that I ſhall defer to another opportunity. The particular ſubject of this treatiſe, is Animal Heat, I ſhall therefore only mention the general principles and laws, upon which my opinion is founded, and ſo much of the theory, as will be found neceſſary to explain my ideas, of the nature and compoſition of heat.

It appears evident to me, that there is one grand principle of nature, which Chemiſts have entirely overlooked. It is the great principle of Elaſticity and Fluidity. It is that wonderful, ſubtil, active, univerſally diffuſed *Æther*, hinted at by the great Sir Iſaac Newton *; and by that name I ſhall diſtinguiſh it.

When we conſider the amazing elaſticity and rarity of light: the activity, and irreſiſtable permeating power of fire: the mobility, and velocity of the electric fluid: their great ſimilarity in many reſpects: their mutual action, and very conſtant attendance, upon each other; can we avoid ſuppoſing that they have ſome principle, or principles in common amongſt them? Do not the operations of Chemiſtry prove it? Do not they all impart phlogiſton to certain ſubſtances, in certain circumſtances? And when we conſider their general rarity, mobility and elaſticity, can we refuſe our aſſent to Sir Iſaac Newton's conjecture, that there is an *Æther*, a ſubtil medium in nature, whoſe operations ought not to be unnoticed?

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* Newton's Opticks. Qu. 18 &c. page 323 &c.

ticed? And is it an improbable conjecture, that this Æther, is the great active principle in each of them; and likewiſe in every other combination of matter, poſſeſs'd of elaſticity or fluidity?

By adopting this principle, and adding to it three others, (which none I think will deny the exiſtence of, except the Lavoiſierians,) I think it poſſible, to ſolve the phenomena of Nature, and conſequently of Chemiſtry, in a more eaſy, natural, ſimple and ſatisfactory manner, than any other hypotheſis hitherto offered to the world, hath done, or can do.

I therefore place *Æther* as the firſt principle or Element of nature; *Phlogiſton* or the principle of Fixity, and Solidity, as the ſecond; an *Acid* the third; and *Earth* the fourth.

Æther and Phlogiſton, have an affinity to each other; and according to the proportions, or circumſtances in which they unite, they form *Light*, *Fire*, or the *Electric Fluid*. Perhaps light hath a redundance of phlogiſton, and the electric fluid of æther; whilſt fire, or the matter of heat, is a complete ſaturation of each with the other.

Æther likewiſe readily, and intimately unites with the acid principle; and this combination forms *Pure Air.*

Æther hath no affinity with Earth, unleſs the earth be already combined with an acid, or phlogiſton; in which caſe the Æther will enter into combination with it, on account of its attraction to the acid, or phlogiſton there preſent.

Phlogiſton unites with Æther, as above mentioned; with Earth it intimately combines, forming Metals &c. but to the Acid Principle it hath no affinity, unleſs through the mediation of Æther, or earth.

The Acid Principle and Earth, ſtrongly attract and unite with each other.

With theſe general principles, and laws, I will now endeavour to explain thoſe chemical phenomena, which the theories before mentioned, ſeem'd not to do in a ſatisfactory manner; and I hope 'ere long, to be able to give ſo clear an explanation of many other effects and appearances in Chemiſtry, hitherto imperfectly or confuſed accounted for; as will render theſe principles ſo clear, and ſatisfactory to others, as at preſent they are to myſelf.

Firſt of all I ſhall conſider the calcination of metals.

If a Metal be expoſed to the action of heat, in the open air, or in a ſufficient quantity of pure air, which is the only part of atmoſpheric air required; it loſes its phlogiſton, and becomes a Calx, heavier than when in its metallic ſtate; at the ſame time the pure air diſappears.

A Metal is compoſed of earth and phlogiſton; Pure Air of æther and the acid principle. By the action of heat, theſe four principles are ſo far ſeparated from each other, and their affinities ſo weakened, that a double decompoſition takes place; the phlogiſton of the metal combines with the æther of the pure air, and forms heat or fire; while the acid principle, now diſengaged, unites with the earth and forms a Calx, heavier than before, in proportion to the quantity of acid combined with it; and conſequently the pure air muſt diſappear.

If now this Calx, which as before we will ſuppoſe the calx of mercury, be expoſed in a cloſe veſſel, to a ſufficient degree of heat: the mercury is revived, and the receiver contains pure air: which is thus eaſily explained.

The Calx is compoſed of earth, and the acid principle: Fire of æther and phlogiſton.—If the heat be ſufficiently great, to ſeparate the earth and acid, beyond the ſpheres of their attraction: the Earth ſeizes upon the phlogiſton of the heat and revives; at the ſame time, the Acid of the calx, and Æther of the fire, being both diſengaged, combine, and form Pure Air; and conſequently the metal, now deprived of its acid, muſt loſe that additional weight, which it had acquired by uniting with it, when a calx.

The other experiment, where the calx of ſilver was reduced by expoſure to Light, admits of a ready ſolution. The Calx contains an earth and acid; Light is formed of æther, with phlogiſton either ſuper-abundant, or looſely combined. The earth of the calx then ſtrongly attracting the phlogiſton of the light, and the æther of the light, the acid of the calx, produce a double decompoſition;

compoſition; in conſequence of which, two new compounds ariſe; the earth unites with the phlogiſton, and forms Silver in its metallic ſtate; and I ſhould ſuppoſe that the æther, with the diſengaged acid of the calx, muſt form pure air; but that I am not certain of from experience.

When Phoſphorus is burnt, its acid is left, and the quantity of the acid is greater, than that originally contained in the phoſphorus; and upon theſe principles it could not be otherwiſe. For Phoſphorus is compoſed of acid and phlogiſton, with a certain proportion of æther, without which the acid could not unite with phlogiſton; the proportion of which æther, entering into its original compoſition, gives it its peculiar properties, different from every other acid, where the proportion of æther entering into its compoſition, is different. When therefore this phoſphorus is burnt in contact with pure air, (without which indeed it cannot be accended) the phlogiſton of the phoſphorus, unites with the æther of the pure air, and forms Fire or Flame; at the ſame time, the diſengaged Acid of the air is depoſited, and uniting with the diſengaged phoſphoric Acid, gives the increaſe of quantity and weight.

This is all at preſent that I ſhall conſider, of the Via Sicca of Chemiſts. I ſhall now apply the ſame principles, to explain the calcination of Mercury, Viâ Humidâ.

If Mercury be diſſolved in ſtrong Nitrous Acid, it gives a Calx of Mercury, and Nitrous Air.

I ſhall not at this time, enter further into the ſpecification of the parts, of which Nitrous Acid is compoſed, than that it chiefly conſiſts of the acid principle, with a certain proportion of æther, (not ſufficient to enable it to take the form of pure air,) united to water; the Mercury as before intimated, chiefly conſiſts of Earth and Phlogiſton. When theſe ſubſtances therefore are expoſed to each other, the earth attracts enough of the acid to give it the form of Calx, and at the ſame time its phlogiſton becomes at liberty; it therefore ſeizes upon the æther diſengaged from acid now combined with the earth, and eſcapes in the form of heat; but the æther combined with the acid, not being in ſo great a proportion as it is in pure air, is not ſufficient to ſaturate all the phlogiſton, diſplaced by the acid from the earth of the mercury: therefore, the remaining part of the phlogiſton, ſeizes upon the æther combined with the remaining acid; but that acid being only partly ſaturated with the æther united to it, and with which it hath a ſtrong affinity, refuſes to quit it entirely, as having nothing to combine with in its place; therefore, the æther hath its attraction divided between the acid and phlogiſton, forming a cloſe union with neither; in conſequence of which looſe attraction, the ſpace they occupy is much greater, than when the Acid and Æther were intimately combined, becauſe they now expand themſelves into the form of an Elaſtic fluid, to which Chemiſts give the name of Nitrous Air; which therefore is Æther, having its attraction divided between Phlogiſton and the Acid principle; to both of which it hath an affinity, but cannot intimately combine with either, on account of its attraction for the other; which muſt inevitably prevent a coaleſcence, becauſe the Phlogiſton and Acid have no attraction for each other.

If this Calx be expoſed to a ſufficient degree of heat, ſo as to ſeparate the Earth and Acid, beyond the ſphere of each other's attraction; the Earth will attract phlogiſton from the heat, while the other component part of heat, the Æther, will unite with the Acid diſengaged from the Earth, and form pure Air, as before explained.

The whole of the Acid employed then, is contained in the nitrous air of the firſt proceſs, and the pure air of the ſecond. If theſe two elaſtic fluids be mixt together, the phlogiſton of the nitrous air, will unite with a ſufficient quantity, of the Æther of the pure Air, and eſcape in the form of heat: while the Acid of each uniting, and ſtill retaining a ſmall quantity of Æther, to which the acid principle hath ſo ſtrong an affinity, their elaſticity and bulk will be diminiſhed, and Nitrous Acid again produced. But the quantity of nitrous acid thus recovered, is not equal to the quantity originally employed, becauſe all the pure Air is not decompoſed, and the other part remains there united with Æther.

I have ſaid that the Electric Fluid is compoſed of the ſame principles as Light, and Fire, i. e. of Phlogiſton and Æther; but either in different proportions, where the Æther predominates; or otherwiſe, in a different ſtate of combination; in proof of which I ſhall offer the following experiments.

Dr. Prieſtley tranſmitted the Electric Shock, through a bubble of Air confined by Nitrous Acid, the conſequence was, every ſpark made a conſiderable addition to the quantity of air, which appeared to be the pureſt dephlogiſticated air.*

The Acid Principle not being fully ſaturated with æther, in the nitrous acid, attracted it from the the Electric Fluid paſſing through it, and then became pure Air; and I ſhould ſuppoſe, that the phlogiſton diſengaged from that Æther, muſt phlogiſticate the remaining acid.

But if the Electric Fluid be tranſmitted through pure air, confined by Lime-water, or Cauſtic Lixivium: the pure air diſappears, and an Acid is precipitated.

The reaſon is evident: the acid principle in the pure air, hath an attraction for the earth contained in the fluid by which it is confined: and therefore the attraction between the Æther and the Acid in the pure Air, is weakened; in conſequence of which, this Æther will attract the phlogiſton, looſely combined in the Electric Fluid, and paſs off with it in the form of heat, or light; and the Acid will be left at liberty to unite with the Earth contained in the fluid beneath. When the Cauſtic Lixivium was employed, Mr. Cavendiſh found, that the acid combined with the alkali, ſo as to form a neutral ſalt; which ſalt he found to be Nitre.

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* Prieſtley's Experiments and Obſervations. Vol. 3. p. 339.

And now, though the nature and compoſition of *Water*, is not immediately connected with the ſubject of this treatiſe, yet as it is at preſent an object to which Chemiſts pay particular attention, permit me to give an explanation of its compoſition, according to the principles herein propoſed.

Water is produced by a perfect ſaturation of the four Elemental Principles with each other; the Acid is half ſaturated with Æther, and half with Earth; the Earth with Acid and Phlogiſton; Phlogiſton with Earth and Æther; and Æther with Phlogiſton and Acid; ſo that the whole forms a perfect neutral, where each principle is ſaturated, by an equal attraction to the two other principles with which it hath an affinity, in conſequence of its not having a ſufficient quantity of any one other principle, to enable it to take a ſimpler form. As for inſtance, the Acid Principle, hath not Æther enough to enable it to take the form of pure Air, therefore to ſupply the want, it attracts the Earth; and ſo with the reſt.

If this Water be ſo heated as to take the form of Steam, and that ſteam be tranſmitted through a red hot iron tube, or a tube containing iron red hot, that degree of heat will ſeparate the Earth and Acid of the Water, beyond the ſpheres of of each other's attraction, in conſequence of which, the Earth of the Water will ſaturate itſelf with phlogiſton from the Iron: and the Earth of the Iron, will unite with the now totally diſengaged Acid of the Water. The Acid and Iron, will form a *Calx* or *Slag;* and the Earth of the Water now ſaturated with much phlogiſton, and by means of that phlogiſton retaining the Æther of the Water, will form *Inflammable Air.*

Inflammable Air therefore, conſiſts chiefly of an Earthy baſe, united to much phlogiſton; but that phlogiſton retains a certain proportion of Æther, which gives it its Elaſticity; and perhaps that Æther may attract a ſmall portion of Acid; but the predominant principle of Inflammable Air is *Phlogiſton*, and the baſe, *Earth*.

This Analyſis of Water is proved by Syntheſis: for if Inflammable Air and Pure Air be exploded together, the reſult is Water and Flame. For pure air being compoſed of Æther and Acid, and Inflammable Air chiefly of Phlogiſton and Earth, part of the Æther and Phlogiſton will unite, and eſcape in the form of fire, heat or flame; in conſequence of which, the Acid not having a ſufficient quantity of Æther, nor the Earth of Phlogiſton, to ſaturate them, and enable them to keep in their aëriform ſtate, they exert that power of attraction, now left unſatisfied, upon each other, and by that compound union form Water; the Acid being partly ſaturated with Æther, and partly with the Earth already diſpoſed to the union, by being deprived of part of its phlogiſton.

Allow me to bring one more proof, before I diſmiſs the ſubject.—When Dr. Prieſtley expoſed Calx of Iron, in Inflammable Air, to the action of ſolar light, in the focus of a burning Lens, the Iron was revived, inflammable Air abſorbed, and Water produced.*

The violent heat deſtroyed the union of the Earth and Acid, in the Calx, in conſequence of which the Earth exerted its action upon the ſuperabundant phlogiſton of the Inflammable Air, with which it combined, and became Iron; at the ſame time, the diſplaced Acid, united with the Æther of the Inflammable Air: but that not being ſufficient to ſaturate it, it ſeized alſo upon the Earth of the Inflammable Air, now diſpoſed to that union, by the loſs of the Phlogiſton taken from it by the revival of the Iron; and the reſult of that union of the four principles, was *Water*.

Water therefore is compoſed, of Earth half ſaturated with Phlogiſton, united to the Acid Principle half ſaturated with Æther.

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* Prieſtley's Experiments and Obſervations, Vol. 3. p. 82.

The only phenomenon that at preſent remains to be conſidered, is, the Phlogiſtication of Nitrous Acid, and production of Pure Air, by expoſing pure Nitrous Acid to the action of Light.

Pure Nitrous Acid is compoſed of much Acid, ſome Æther, and Water; but as Water hath been ſhewn to contain an Earth partly phlogiſticated: Nitrous Acid may be ſaid to contain much Acid, ſome Æther, and an Earth half phlogiſticated. When this Acid is put into a phial, where part of it can expand into the form of vapour, with heat ſufficient to enable it to take that form, and thus expoſed to the light, the Earth having an opportunity of acquiring its full quantity of Phlogiſton from the Light, where it is looſely combined with Æther, quits the Acid, ~~and~~ and uniting with the Phlogiſton, diffuſes itſelf in the Nitrous Acid beneath, to which it gives colour; at the ſame time, the Acid diſengaged from the Earth is left at liberty, to exert its full power of attraction upon the Æther: but not having enough already combined with it, it ſeizes upon that diſengaged from the Light, and thus takes the form of Pure Air.

And now having ſaid as much as I think neceſſary concerning my Chemico-Philoſophical principles, and their application to the ſolution of ſome of the moſt common and ſtriking Phenomena of Chemiſtry, to explain my idea of the *nature*, and *compoſition* of Heat or Fire; I ſhall at this time drop the ſubject, and immediately proceed, to the particular object of my preſent enquiry.

ON

ANIMAL HEAT.

SECTION I.

Living Animals have the power, or property, of generating, or producing heat.

IT hath long been obſerv'd, that many Animals, particularly thoſe with double hearts, forming the two firſt claſſes of Linnè,* have a very conſiderable degree of ſenſible warmth ; that the degree is nearly the ſame in the winter's cold, and ſummer's heat : and conſequently, that a living animal body, in a healthy ſtate, hath the property, of keeping itſelf at nearly the ſame certain natural temperature, let the temperature of the ſurrounding atmoſphere be what it may.

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* DIVISIO Naturalis Animalium ab interna ſtructura indicatur :

COR biloculare, biauritum ; { Viviparis. Mammalibus,
Sanguine calido, rubro. { Oviparis. Avibus.

Syſtema Naturæ. Caroli a Linné. page 19.

The natural heat of the human body, is about 98° of Fahrenheit's Thermometer; and that of ſome other genera; of theſe two claſſes, conſiderably higher; particularly different ſpecies of Birds; in ſome of which the heat is ſo great, as to raiſe the thermometer to 106, or 108 degrees.*

But if an animal be deprived of life, it loſes its temperating power, and ſoon becomes of the ſame degree of heat, with the earth upon which it lies; or the air which ſurrounds it.

If an Animal (which, if not otherwiſe expreſs'd, is throughout this treatiſe to be ſuppos'd both living and healthy) be expos'd, to a ſharp froſty air for a day, a week, or a month, its general temperature is not altered.

Sheep, oxen, horſes, hares &c. are frequently expoſed to froſt and ſnow, for weeks together: when the air that ſurrounds them, the ground that ſupports them, and the food they eat, are cooled down to the freezing point, 32°, and ſometimes far below it; yet at the expiration of a day, a week or month, the heat of the animal is ſtill the ſame, (ſtill 98°.) 'Tis certain therefore, that the animal thus expoſed, generated heat; becauſe it was at the firſt to a certain degree warmer than the ſurrounding medium: it continually communicated heat to every thing in contact with it: and yet at the end of the day, week or month, was as warm as at firſt; tho' perhaps the ſurrounding atmoſphere might have become colder. Indeed, if it had not generated heat, it muſt have been affected by the ſurrounding cold, juſt in the ſame manner, as it would, if it had been kill'd at the moment of expoſure.

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* Martine's Eſſays and Obſervations &c. p. 141 &c.

To offer further proofs of this property of generating heat, in the two claſſes of animals mentioned, (and which are particularly to be underſtood as the ſubjects meant in this diſquiſition), would be ſuperfluous; as it appears ſufficiently evident from what is already offer'd; and is univerſally allowed, by every one who hath given the leaſt attention to the ſubject.

It appears evident then, that ſo long as an Animal retains the living principle, the functions of the body are duly performed, and a certain degree of heat is generated.

That as ſoon as the living principle is deſtroy'd, the exerciſe of every function ceaſes: the generation of heat is diſcontinued: and the body ſoon becomes of the ſame degree of heat with the ſurrounding medium; conſequently, the living principle gives excitability to the animal ſolids; and one conſtant effect of excitement, is *Animal Heat.*

But, If an animal, perfect in the exerciſe of all its functions, be deprived of *Food*, or *Air*: it dies, and its heat becomes extinct; conſequently, both Food and Air, are eſſentially neceſſary to the Support of animal life, and its concomitant, Animal Heat.

In the next Section therefore will be conſider'd, why they are ſo.

SECTION II.

Food and Air are eſſentially neceſſary, to the Support of Animal Life and Heat.

IN the preceding Section it appears, that the eſſential characteriſtic of life in animal bodies, is excitability; and that one invariable conſequence of excitement is heat; therefore, ſo long as an animal lives, ſo long will its body maintain its natural degree of warmth; unleſs affected by diſeaſe, or placed in unfavorable circumſtances.

If an Animal be deprived of Air, it ſoon dies, as is evident from experiments with the Air-pump; from drowning, hanging &c.

If it be deprived of Food, its vigour gradually abates: it conſumes away: and although it may have plenty of Air—it dies. Theſe two facts are ſo well known, and univerſally allowed, that they need but be propoſed, to be granted.

May we not reaſon then in the following manner?

A healthy animal, if deprived of food, or air, or both, ſoon dies, and its heat becomes extinct; but if ſupplied with food and air, for a year for inſtance, it will live and generate heat for a year; no unforeſeen circumſtance intervening. All the heat therefore that this animal generates during the year, muſt be compoſed of certain parts of the food and air employed to ſupport its functions; for the healthy animal which dies for want of food, or air, wants not the power, or property of generating heat, but the materials wherewith to produce it; it does not die for want of excitability: but for want of a proper ſtimulus, to excite the due actions of the living ſolids; and matter proper for theſe different functions, to exert themſelves upon.

Food and *Air* therefore are eſſentially neceſſary to ſupport *Animal Heat*; and animal heat itſelf, is a compoſition of certain parts of that food and air, modified, and combined, by the proper exerciſe of the natural animal functions.

Animal life, ſeems to be a *gentle Combuſtion;* and an animal producing heat, in many reſpects, may be compared to a burning lamp; the heat in both

both caſes ariſing from the ſame cauſe. A living animal produces heat; ſo does a burning lamp. If an animal be not ſupplied with air, it dies, and its heat is extinguiſhed; ſo it is with the lamp. The air that hath been burnt by the lamp, deſtroys animal life; ſo the air that the animal hath breathed, puts out the lamp. A certain quantity of air, will ſupport an animal for a certain time, but no longer; ſo it will keep up the flame of the lamp, for a certain time only. Fixt and phlogiſticated airs deſtroy animals; ſo likewiſe do they extinguiſh the lamp. The air breathed by animals is diminiſhed in quantity; ſo it is by the burning of the lamp. A living animal, and a burning lamp, therefore exactly agree in requiring the ſame kind of air to ſupport them, and producing the ſame effects upon the air, to which they are expoſed.

But they do not reſemble each other *only* in producing heat, and requiring the ſame kind of air: for if an animal hath not freſh ſupplies of food, as well as air, after a certain time it dies, and becomes cold; juſt in the ſame manner, as the lamp dies out, if not duly ſupplied with oil.

Since then, that part of the air deſtroyed by reſpiration, is the ſame, as that loſt by combuſtion: and ſince the ultimate effect is the ſame, in both operations, that is, the production of heat; is it not allowable to ſay, that the food affords to the animal, the ſame principle, that the oil affords to the lamp? For ſince the effects are the ſame, the cauſes muſt be ſo too. Oil, therefore, affords the principle of inflammability, or phlogiſton, to the lamp: and conſequently, the *food* of animals, ſupports the functions of life, and the generation of *heat*, by ſupplying *phlogiſton* to the *Animal Syſtem.*

The Chemical analyſis, of ſuch ſubſtances, as are proper to ſupport animal life, confirms this opinion; for no ſubſtance affords proper nouriſhment, which contains not Phlogiſton in its compoſition; and the inſtantaneous ſupport, and refreſhment, perceived by thoſe who are much exhauſted, upon taking certain inflammable ſubſtances into the ſtomach, ſuch as wine, ardent ſpirits, eſſential oils &c. ſtill further confirm it. Very different matters therefore, will ſupport animal life, if they contain phlogiſton, as an ingredient, ſeparable by the animal proceſs; ſo likewiſe very different ſubſtances will ſupport the flame of a lamp, if they contain the principle of inflammability, ſeparable by the heat of Combuſtion ; ſuch are oils; ardent ſpirits &c. &c.

It appears evident therefore from the preceding conſiderations,

1ſt. That the exerciſe of the animal functions produces heat.

2dly. That *animal heat*, as well as animal life, is ſupported by food and air.

3dly. That animal heat is formed from ſome part of the food, united to ſome certain other part, ſupplied by the air.

4thly. That the ſame part of the atmoſpheric air, that produces heat in combuſtion, by its union with phlogiſton : is taken from it by the reſpiration of animals; and conſequently,

6thly. That as heat is produced both by combuſtion, and the vital functions of animals, it muſt ariſe from the ſame cauſe ; therefore, as the ſame part of the air is deſtroyed by both, the food muſt furniſh the animal with phlogiſton, as oil does the lamp; and the combination of this phlogiſton with the pure air, affords animal heat to the one, and the heat of combuſtion to the other.

The next thing to be conſider'd is, by what function, or functions of the Animal Syſtem, this combination of the phlogiſton of the food, with that peculiar part of the air, ſo as to form animal heat, is effected; which, will be the ſubject of the next Section.

SECTION III.

The particular functions of the animal ſyſtem, which combine the phlogiſton ſeparated from the Food, with a certain part of the atmoſpheric Air, ſo as to produce heat, inveſtigated.

IT hath been mentioned, and is univerſally allowed, that an animal deprived of the living principle, does not generate heat; it was alſo intimated, that the eſſential characteriſtic of life is excitability, and heat the invariable conſequence of excitation; or in other words, that heat is produced, by the action of the living ſolids, upon the ſubſtances which excite them.

The phenomena of life therefore, are produced, when the excitability of the parts of an animal, are rendered active, or duly excited, by the application of proper ſtimulants.

Since then the preſence of the vital principle, is known by excitability: and heat is the conſequence of excitation: it ſeems, that heat is produced by *action*, or *exertion*, of every kind; but, the only parts of the animal ſyſtem, which are active, excitable, or capable of exertion are the muſcles, or at leaſt contain muſcular fibres in their texture; therefore it muſt follow, that the *muſcles*, or *muſcular fibres alone*, produce heat during the time of their excitation. But, if the nerves that enter into any involuntary muſcle, or muſcular part, be cut, or compreſſed, ſo as to prevent the communication between the muſcle and the brain, or medulla ſpinalis, that muſcle ſoon loſes its natural excitability, and conſequently can produce no heat, becauſe not capable of excitement, by which alone animal heat is produced. Again, if the nerves extending from the Brain, or medulla ſpinalis, to a voluntary muſcle, be cut or compreſſed, the muſcle cannot be thrown into action, by the moſt violent exertions of the will; conſequently it cannot be excited, or generate heat.. The Nerves therefore in a quieſcent ſtate give excitability, and during the action of the brain, convey excitement to the muſcles.

The involuntary muſcles are diſtributed to thoſe parts of the body, which perform the vital functions; which are thoſe that ſupport and preſerve the ſyſtem; as chylification, the circulation of the blood, ſecretion, excretion &c. Reſpiration is in a certain degree involuntary, yet ſubject to the exertion of the will. Theſe muſcles receive excitability from the nerves, but excitement from the influx of the nervous energy, tranſmitted from the brain, in conſequence of the ſtimulus ~~of the~~ of the ſolid or fluid matters, applied to thoſe nerves.

The voluntary muſcles, are thoſe not immediately concerned, in nouriſhing or ſupporting the ſyſtem, and are chiefly loco-motive; the natural actions of theſe, are not excited by the application of ſtimulants, but by the determinations or volitions of the mind.

Voluntary muſcles then, are thrown into action by the influx of the nervous energy, or fluid, tranſmitted or forced through the nerves, by the impulſe of the brain : or that property of it which we call volition ; the proximate cauſe of which tranſmiſſion, ariſes in the brain ; whilſt involuntary muſcles are thrown into action, by the influx of the nervous energy, tranſmitted through the nerves, by the impulſe of the brain, the proximate cauſe of which is, certain ſenſations or feelings, communicated to the brain by the nerves, in conſequence of the actions of certain ſtimulating ſubſtances, upon their extremities. unintelligible

That there is an *energy*, or *fluid*, tranſmitted from the brain, through the nerves, to the muſcles, during their action, is evident from this, that while a voluntary muſcle is in action, if its communication with the brain be interrupted, its action ceaſes, although the volition remains; this ceſſation from action, does not ariſe from the muſcle wanting excitability, or the brain excitement: but from the excitement of the brain being no longer conveyed by the nerves to the muſcle; 'tis evident therefore, that the nerves convey excitement to the muſcles, and *that* muſcular excitation, we call action, or exertion.

But, if this exciting power be tranſmiſſable from the brain, through the nerves, and be capable of producing ſuch powerful effects, when communicated to the muſcular fibres: it muſt be an *entity*, or powerful agent of ſome kind; poſſeſſed of vaſt mobility, and ſubtilty ſo great, as only to be known by the effects it produces in the Animal Syſtem; and as mobility and ſubtilty, are only compatible with fluidity, the energy of the brain muſt be a *fluid*, which in conformity with cuſtom, will hereafter in this treatiſe, be called the *Nervous Fluid.*

It appears then from the preceding conſiderations, that a muſcle is thrown into action by the influx of the nervous fluid; and that one invariable conſequence of that excitation, is the production of animal heat; conſequently, the quantity of heat generated by an animal, will be proportionate to the quantity of muſcular exertion: and that to the quantity of nervous fluid, tranſmitted from the brain, through the nerves, to the fibres of the muſcles in action. In proof of this concluſion, the following obſervations and Experiments are offered.

Obſervation 1. If an animal, a Man for inſtance, in good health, be expoſed to a *temperate* air, in a ſtate of *reſt*, the quantity of heat generated by the continual action of the *involuntary* muſcles, will be ſufficient to maintain his natural temperature of 98°; by which the ſolids receive a natural ſtimulus, the fluids retain their proper mobility, and all the functions of digeſtion, nutrition,

trition, circulation, ſecretion, excretion &c. are duly performed, and a ſufficient quantity abounds to carry off the perſpirable matter, by evaporation from the ſurface.

Obſ. 2. If a man, expoſed to a *froſty air*, continues at *reſt*, the *involuntary* muſcles, by their natural action, *cannot* generate ſufficient heat, to keep every part of the body at its natural temperature; becauſe the coldneſs of the ſurrounding medium, carries off the heat faſter than they can produce it; conſequently, the ſolids and fluids of the extremities, and at the ſurface of the body, will become frigid, the fibres torpid, and the blood returning cold to the heart, will render it torpid and weak alſo. If theſe circumſtances continue, the torpor gradually increaſing: the circulation becoming ſlower and weaker: and the generation of heat diminiſhing, will ſoon render the body as cold as the air which ſurrounds it, and attracts its heat; and conſequently, *death* muſt enſue.

Obſ. 3. But on the contrary, when a Man expoſed to a *froſty air*, perceives the coldneſs and torpor ariſing from his body being deprived of its heat, faſter than the involuntary muſcles can furniſh it, If he throws the *voluntary* muſcles into action, by *exerciſe*, the quantity of heat generated by the *united* actions of both the voluntary and involuntary muſcles, will be ſufficient to warm every part, and recover and maintain his natural temperature; although the air ſtill ſhall continue to attract the heat from the ſurface as before. The quantity of heat neceſſary, to keep up the natural warmth of the body, and afford a continual ſupply to the cold froſty air around it, muſt therefore be very conſiderable; and a great part of it muſt be generated by the actions of the *voluntary* muſcles, becauſe the involuntary muſcles *alone*, could not keep the body from ſtarving, and conſequently ſoon becoming lifeleſs and cold as the air to which it was expoſed.

But ſince an animal at reſt, is ſupplied with ſufficient heat by the action of the *involuntary* muſcles alone, to ſupport its natural warmth, and all its functions in a *temperate* atmoſphere: 'tis evident, that if the *voluntary* muſcles alſo be thrown into action, a *greater* quantity of heat muſt be produced, and thrown off from the ſurface in any given time, than when they were at reſt, and the involuntary muſcles alone were in action. To prove that this concluſion is in reality a fact, I made the following Experiment.

Experiment 1.

The temperature of the atmoſphere being 63°. of Fahrenheit's thermometer, I took two pints of water from a pump, its temperature 56°. put it into a bladder, and introduced my naked hand into the bladder and water; when ſitting down I remained at *reſt* for 15 minutes. I then withdrew my hand, and found that the temperature of the water was 63°. ſo that my *hand* during 15 minutes, while my body was at *reſt*, and the *involuntary* muſcles *alone* were in action, had thrown off *heat* ſufficient to raiſe the temperature of *two* pints of water, from 56 to 63°.; therefore it had communicated 7°. of heat.

Experiment 2.

I then introduced my other hand into two pints of water, from the ſame pump, and of the ſame degree of heat as the former, i. e. 56, contained in another bladder; I then threw the *voluntary* muſcles into ſtrong *exerciſe* for 15 minutes;

at the end of which time, I found the temperature of the water to be 66°. ſo that my *hand* during a quarter of an hour's exerciſe, had raiſed the temperature of *two* pints of water from 56 to 66°. that is, had communicated 10°. of *heat*: conſequently, the exerciſe of the voluntary muſcles in 15 minutes time, had produced ſo much heat, as raiſed the temperature of two pints of water 3°. that is, from 63°. (to which, by experiment 1ſt, the action of the involuntary muſcles might be ſuppoſed to have raiſed it,) to 66°. only by the heat flowing off, from ſo ſmall a part of the ſurface of the body as the hand, and that too one of the extremities, where the torpor at firſt produced, might be ſuppoſed to check the circulation, and conſequently to leſſen the quantity of heat it would otherwiſe have thrown off, proportionate to the reſt of the ſurface,

But thinking that If I had taken more time, or leſs water, in trying the experiments, the difference of the reſults would have been greater, I made the following experiments.

Experiment 3.

The Thermometer being at 59°. in the open air, I introduced my hand into a bladder containing *one* pint of water, at 56°.; after the expiration of 15 minutes, during which time all the *voluntary* muſcles were kept free from exertion, I found that the temperature of the water was raiſed to 65°.; conſequently my hand had communicated to the pint of water 9°. of heat; that is, had raiſed it from 56 to 65°. in 15 minutes, the *involuntary* muſcles *alone* being in action; for the heat communicated by the air at 59, to water at 56°, in ſo ſhort a ſpace of time, was not worth notice; but in Exp. 1ſt. where the air was 63, and the water 56, ſome allowance might have been made, if the experiment had required ſuch nicety.

Experiment 4.

The ſame day I introduced my other hand into another bladder, containing *one* pint of water, of the ſame degree of heat with the former. i.e. 56; I then threw the *voluntary* muſcles into ſtrong exerciſe, which I continued during the ſame ſpace of 15 minutes; when withdrawing my hand, and introducing the thermometer, I found the heat of the water was 73°· : conſequently, the united actions of *both* involuntary and voluntary muſcles, during 15 minutes time, had generated ſo much *heat*, that beſides preſerving the temperature of the body at 98, in the air at 59°· ſo much had been thrown off from the ſurface, that even that ſmall part of it, the *hand*, had communicated ſo much *heat* to *one pint* of water, as had raiſed its temperature from 56 to 73°· that is, 17°· ; but it ſeems from Experiment 3. that the involuntary muſcles *alone* would have communicated 9°· ; conſequently the the action of the *voluntary* muſcles, had communicated the other 8°· If then the action of the voluntary muſcles during 15 minutes, generated ſo much heat as raiſed the temperature of one pint of water from 65 to 73°· by the heat thrown off from the hand : how great muſt have been the quantity thrown off from the whole ſurface, which that muſcular exertion had generated !

But although ſo great a quantity of heat is generated by muſcular action, the muſcles *themſelves* afford not any part of its compoſition, but are only the *agents*, which combine the principles of which it is compoſed together ; and one eſſential part is furniſhed by the *nervous fluid*, without which the muſcles can neither act, nor produce heat.

It occur'd to me, that perhaps it might be objected, that this increaſe in the quantity of heat, thrown off in conſequence of exerciſe, might not have been produced by the increaſed influx of the nervous fluid, but by the increaſed action, motion, attrition, or friction between the different particles of which the ſolids and fluids are compoſed, which muſt take place in great exerciſe of the muſcles. Therefore, to convince myſelf whether increaſed muſcular *motion* was neceſſary, to produce an increaſe in the quantity of heat, generated by an animal in any given time; or, not; I made the following experiments.

Experiment 5.

The temperature of the air in my room was 59°., of the water I employed, 44°., when I immerſed my hand into one pint of it, contained in a bladder; then ſitting *without* voluntary motion, or exertion, for 15 minutes, I found by withdrawing my hand, and introducing the thermometer, that the heat of the water at the expiration of that time, was raiſed to 57°.; ſo that my hand

and the air in the room together, had communicated to it 13°. of heat.

Experiment 6.

I then (the temperature of the air in the room, and of the water, being the ſame as in the former experiment) introduced my other hand, into the ſame quantity of the water, in another bladder; and ſeated myſelf with my back againſt a wall: my feet *ſtrongly puſhing* againſt a large book-caſe, firmly fixt by its weight: and my arms *forcibly ſtretched* out. By this exertion, the gaſtrocnemii, vaſti, glutæi, pectorales, & tricipites brachiales muſcles particularly, were thrown into *ſtrong contraction;* in that ſtate I kept them 15 minutes; conſequently as *free* from *motion* or *friction*, as in the 5th Experiment; at the expiration of which time, by introducing the thermometer, I found the temperature of the water was 62°; but by the 5th Expert. it ſeems, that the air in the room and the hand, by the action of the *involuntary* muſcles *alone*, would in the ſame time have raiſed it to 57: conſequently, by the contraction of theſe few muſcles, *without* any *motion* of their fibres, ſo much nervous fluid had been tranſmitted to, and through them, by the brain and nerves, as by that *immobile* exertion, had been converted into *heat*, ſufficient to raiſe the temperature of *one* pint of water, from 57 to to 62°, by the quantity only thrown off by the hand; which had therefore communicated to the pint of water 5°. of heat; and as the reſt of the ſurface of the body, muſt have thrown off at leaſt an equally proportionate quantity: it is evident, that the *heat* generated by this partial muſcular exertion, where *neither motion* nor *attrition* were concerned, muſt have been *very* conſiderable indeed!

It appears evident therefore, that a *muſcle* is thrown into action or exertion, or in other words, is *excited* by the influx of the *nervous fluid;* ſo that when this nervous fluid, is *not* tranſmitted from the brain, in conſequence of volition or irritation, the voluntary muſcles in the firſt caſe, or involuntary in the ſecond, are not excited.

It is likewiſe evident, that this nervous fluid is a *reality* or *entity*; tranſmitted from the brain, by the nerves, to the muſcles; ſo that when this communication is interrupted, and the *influx* of this nervous fluid to the muſcle is prevented, its action ceaſes.

It is alſo equally clear, that the nervous fluid does not excite a muſcle to act, by becoming *fixt* or *reſident* there: but by paſſing through, or along the fibres of the muſcles; from this fact, that when a muſcle is excited, if the *continual influx*, or *ſtream* of nervous fluid, paſſing from the brain through the muſcle, be interrupted, by tying or cutting the communicating nerve, its action immediately ceaſes.

'Tis alſo as evidently proved, that the *quantity* of heat generated by a living animal, is in proportion to the muſcular exertion: and conſequently to the quantity of nervous fluid paſſing along the fibres of the muſcles. And the laſt Experiment proves beyond a doubt, that this heat is *not* produced by *motion*, or *attrition* of the parts of which an animal is compoſed: but by the *nervous* fluid when, or after paſſing along the fibres of a muſcle, or muſcles.

Since then the tranſmiſſion of the nervous fluid through, or along muſcular fibres, is neceſſary to excite them to action: and ſince the conſequence of that tranſmiſſion or excitation, is the generation of heat; the next thing to be enquired into, is the nature and chemical properties of this nervous fluid.

SECTION IV.

On the Nature, or leading Chemical Principle of the Nervous Fluid.

FROM the preceding conſiderations, the nervous fluid appears to be an eſſential part in the compoſition of heat, ſupplied by the brain.

The Brain itſelf ſeems to be a glandular maſs, ſupplied with a greater quantity of arterial blood in proportion to its bulk, than any other part of the body, except the Lungs, by the carotid and vertebral arteries, which are the firſt conſiderable branches ſent off by the Aorta.

If the quantity of blood ſent from the heart to the brain, be ſuddenly and greatly diminiſhed, or interrupted, in its paſſage through the carotids, the brain wanting that firmneſs, plenitude or tenſion, which the blood veſſels naturally ſupport, becomes collapſed or flaccid; in conſequence of which, it loſes its power of impelling the nervous fluid along the nerves, to the voluntary and involuntary muſcles in proper quantity; hence ariſe relaxation, ſyncope and death, as is evident from great and ſudden loſſes of blood.

If the blood be not duly ſupplied with chyle, prepared by the ſtomach &c. from proper food or nutriment, it ſoon becomes impoveriſhed by the action of the brain, the quantity of nervous fluid ſecreted will be gradually leſs and leſs, till at length the blood becomes quite exhauſted; the Brain thus deprived of ſupport, ſoon parts with its ſlender ſtore to the involuntary muſcles or others, and after a gradual diminution of power and action in all the functions, the ſcenes cloſes in death.

'Tis evident therefore, that the free and equable action of the brain and nerves, depends upon a proper plenitude and firmneſs of the blood veſſels ſupplying the brain: the quantity of nervous fluid upon that of the nutrimental part in the blood: and that upon the food taken into, and digeſted and aſſimilated by the ſtomach, bowels &c. therefore, the nervous fluid is ſupplied by that part of the food, which after due digeſtion and preparation by the ſtomach &c. is abſorbed by the lacteals, and commixt with the blood.

Now, as was before intimated p. 38, all thoſe ſubſtances which afford proper nouriſhment, contain *phlogiſton* as one neceſſary ingredient; and as in caſe of great exhauſtion of the nervous fluid, by violent muſcular exertions &c. the moſt ſudden refreſhment and reinvigoration, is obtained from thoſe matters which contain much phlogiſton, in the moſt detached ſtate, as wine, ardent ſpirits, &c. it is natural to conclude, that the *nervous fluid* contains *phlogiſton*, as one of its eſſential parts; therefore, the food ſupplies the brain with phlogiſton, as certain inflammable matters do the lamp; as was before hinted from analogy, p. 39.

If then, as is preſumed from the preceding conſiderations, the nervous fluid be of a phlogiſtic nature: and heat be produced by the combination of phlogiſton, with a certain part of atmoſpheric air: and the reſpiration of air be as neceſſary to the continuation of animal life, and the generation of animal heat, as it is to the ſupport of the flame of a lamp, and the production of the heat of combuſtion, it will follow, that the air during reſpiration, muſt communicate this eſſential part of its compoſition to the animal body; or rather, to the *blood*, by that natural and neceſſary action expoſed to its influence; and if it be a fact, that blood does imbibe this eſſential part of the atmoſpheric air, when expoſed to its action in the Lungs, during reſpiration, and part with it again, in conſequence of the generation of animal heat: it will be a convincing proof, that a *nervous fluid* does in reality exiſt: that it is of a *phlogiſtic* nature, and by communicating *excitement* to *muſcular* fibres, is left in ſuch a ſtate, as to readily *combine* with the *eſſential* part of the *air*, contained in the *blood*, and thus form the *heat of animals.*

The ſubject of the next Section, will therefore be an attempt, to prove that this eſſential part of Atmoſpheric Air, is really abſorbed by the Blood in its paſſage through the Lungs, during reſpiration.

SECTION V.

On the change produced in the Blood, by its expoſure to the action or influence of Atmoſpheric Air in the Lungs, during reſpiration.

ONE obſervation worthy of attention is, that the ſame quantity of blood paſſes through the lungs, in any given time, as through the reſt of the body; becauſe no blood is tranſmitted from the heart by the aorta, but what is received from the pulmonary veins, immediately after it hath been expoſed to the action of the air in the lungs.

If the blood in the vena cava, or pulmonary arteries be examined, it is found to be of a *dark* red, or *blackiſh* colour; but after having been expoſed to the influence of the air, it is returned by the pulmonary veins to the heart, of a *bright red* colour, to be conveyed by the arteries, to ſupport the functions of every part of the body.

The ſame change of colour, is alſo produced by *expoſing* blood taken *from* the veins of an animal, to the atmoſpheric air; therefore 'tis evident, that this change of colour is effected by the action of the air.

But, if this venous blood, be expoſed to air that hath been reſpired, or burnt 'till it would no longer ſupport life or combuſtion, it does not acquire this florid red colour, but ſtill remains black; or, if this black or venous blood, be expoſed to a proper quantity of common air, that quantity will be diminiſhed, and the reſiduum unfit for either reſpiration or combuſtion.

It appears then, that a certain part of the atmoſpheric air is deſtroyed, decompoſed or abſorbed by reſpiration, combuſtion, and by expoſing to it, a quantity of black or venous blood; and that it is the *ſame* kind of air that is deſtroyed, or abſorbed in each proceſs; and to this part of the common air, Philoſophers have given different names, as Empyreal Air, Vital Air, Dephlogiſticated Air, Air eminently reſpirable &c. but the ſhorteſt and perhaps as good a name for it as any, is that of *Pure Air*, which I ſhall therefore make uſe of through the remaining pages.

Dr. Prieſtley and others, have ſuppoſed, that the change produced by expoſing venous blood to the air, is in conſequence of the air, by its ſuperior attraction, depriving it of phlogiſton, which gives it the dark colour; therefore the air attracting this phlogiſton, leaves the blood of its natural florid colour. If this be the only uſe of reſpiration, 'tis evident that the only change which ought to be produced in the air reſpired, or expoſed to venous blood, muſt be, that it hath received a quantity of phlogiſton, without parting with any thing to the blood; and the only change in the blood, its having parted with phlogiſton, to the air, without having received any thing from it; But, as air ſuffers the ſame change from combuſtion as from reſpiration, it is evident, that if reſpiration renders air impure only by imparting to it phlogiſton; combuſtion alſo muſt render it foul by communicating phlogiſton, without taking any thing from it. But M. Lavoiſier from experiments boldly aſſerts directly the contrary. He ſays * that if Mercury be calcined in vital air perfectly pure, it may be abſorbed to the laſt particle; but if the operation be interrupted before all the vital air be abſorbed, the reſiduum is not in the leaſt altered, that is, it contains no more phlogiſton than was contained in the original quantity of air employed.

If ſo, and ſo I have not a doubt but it is, as the change produced in the air by combuſtion and reſpiration

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* "Les partiſans de la doctrine de Stalh, ſont perpétuellement dans de ſemblables embarras: ſi on leur demande ce qui ſe paſſe lorſque l'on calcine du mercure dans l'air vital, les Phyſiciens anglois répondront qu'à meſure que le phlogiſtique ſe dégage du métal, il ſe combine avec l'air dans lequel on opère, & qu'il le change en air fixe ou en air phlogiſtiqué; mais cette aſſertion eſt encore abſolument contraire aux faits. Lorſque l'on opère ſur de l'air vital abſolument pur, on peut l'abſorber juſqu'à la dernière goutte, & ſi l'on interrompt l'opération avant que l'abſorbtion ait été complète, la portion d'air vital qui reſte n'eſt nullement altérée, elle ne contient exactement que la même quantité d'air méphitique qui étoit contenue originairement dans la totalité de l'air qu'on a employé." Hiſtoire de L'Académie &c. Année 1783. p. 519.

reſpiration is the *ſame*, it will naturally follow, that the *Blood* does *not* impart phlogiſton to the air in the lungs; that the alteration produced in the nature of the air, is the *loſs* of its pure air; and that the change of the colour of the blood from *black* to *red*, is effected by this *Pure Air*, which it hath *abſorbed* during its paſſage through the lungs.

As a further proof that the change produced in the air by reſpiration, is not the acceſſion of phlogiſton, but the loſs of its pure air, I ſhall borrow ſome experiments from my much eſteemed Friend Dr. E. Goodwyn, publiſhed in his valuable Theſis at Edinburgh, 1786.*

He took a quantity of air containing by analyſis, phlogiſticated air 80 parts, pure air 18 parts, and fixt air 2 parts, the whole making 100 equal

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* Diſſertatio medica inauguralis, de Morbo morteque Submerſorum inveſtigandis.

parts. From repeated trials he found, * that the whole received and returned by one reſpiration, gave of phlogiſticated air 80, pure air 5, and fixt air 13 parts, the whole 98 equal parts ; ſo that $\frac{1}{50}$th. part of the whole bulk was loſt. It appears therefore, that the air by one reſpiration had ſuffered a loſs of 13 parts of pure air, and had gain'd 11 parts of fixt air, the quantity of phlogiſticated air being the ſame. The pure air therefore was either abſorbed, or changed into fixt air ; but that it was abſorbed and not changed into fixt air, his 4th Experiment ſeems clearly to prove † : Four ounces of blood from the vena cava

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* *Totus aër, una reſpiratione, receptus, conſtabat ex partibus:*		*Totus aër, una expiratione, redditus, conſtabat ex partibus:*	
Aëris phlogiſticati	80	Aëris phlogiſticati	80
Aëris puri —	18	Aëris puri —	5
Aëris fixi —	2	Aëris fixi —	13
	100		98

p. 40.

† “ *Experimentum quartum.*—Quartuor unciae ſanguinis, e vena cava ovis, in vas vitreum receptae, illico, actioni centum partium aëris atmoſphaerici jam explorati, objiciebantur :

cava of a ſheep were expoſed in a glaſs veſſel to 100 parts of the preceding kind of air: the dull dark colour was preſently changed to red: the volume of air diminiſhed, and about $\frac{1}{30}$th. part of the whole was abſorbed, while the phlogiſticated and fixt airs were not in the leaſt altered, conſequently the part abſorbed was pure air.

When the ſame experiment was repeated with eight ounces of blood, $\frac{1}{20}$th. part of the whole was abſorbed, and that was pure air, the phlogiſticated and fixt airs being in no reſpect altered.

Theſe Experiments prove, that *no* phlogiſton is abſorbed by the air from the blood during reſpiration, as was ſuppoſed by analogy from M. Lavoiſier's obſervations on combuſtion; and conſequently,

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bantur: ecce ſubito, color ſanguinis e fuſco in rubeum vertebatur: volumen totius aëris decreſcebat; ipſiuſque circiter trigeſima pars (ſcilicet quae purus aer erat) evaneſcebat; dum nec fixus aër, nec phlogiſticatus, vel minimùm immutarentur.

Idem experimentum inſtituimus, octo unciis venoſi ſanguinis utentes; tuncque pars totius aëris molis vigeſima, ſub puri aëris forma abiit; caeteris aëris portionibus haud mutatis." p. 45, & 46.

ſequently, that the florid *red* colour given to the blood, by expoſing it to the air, is *not* produced by its parting with phlogiſton to the air, and therefore, its *black* colour is *not* owing to the ſuperabundance of phlogiſton contained in it. It appears likewiſe evident, that the blood circulating through the lungs, does not produce *fixt air* by decompoſing the pure air; becauſe when it abſorbs pure air, and acquires its florid, red colour, *out* of the body, no fixt air is produced. Perhaps this fixt air, is ſecreted by the exhalent veſſels of the lungs, and thrown off as an excrementitious matter: upon the ſame principles, as the vapour of perſpiration is thrown off from the ſurface of the body.

From the preceding experiments &c. it ſeems at leaſt very probable, that the opinion of Dr. Prieſtley, and others, who ſuppoſe the *chief* uſe of *reſpiration* is to *free* the blood from a redundant phlogiſton, is erroneous; and that the *real* uſe is, to *ſupply* the blood with pure air.

The cauſe of *death* then in animals expoſed to impure air, is *not* the *phlogiſton* retained in the blood, for want of pure air to carry it off: but the *want* of a *proper ſupply* of that pure air to the blood, which by circulating through the muſcles &c. hath been deprived of it. For if the retention of phlogiſton in the blood, be the cauſe of death, on account of its ſedative power, why does it not produce the ſame deleterious effects upon the *right* auricle and ventricle of the heart, as it is ſuppoſed to do by paſſing unaltered to the *left?* but there it ſhews no ſuch effects: therefore, the cauſe of death in this caſe, *cannot* be the ſedative power of phlogiſton, retained in the blood.

The Pure Air therefore, abſorbed by the blood, ſeems to act as a ſtimulus, or to be ſome way or other neceſſary to excite and ſupport the action of the heart; and if of the heart, that alſo of every other involuntary muſcle; in proof of which I ſhall borrow another of Dr. Goodwyn's experiments, which for the conviction it carries along with it, I eſteem as a moſt beautiful, though cruel experiment.*

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* "*Experimentum ſeptimum*.–Cani ſuper menſam religato ſternum ſuſtulimus; tunc pulmones eodem pacto, quo in experimento ſexto, ope follis, aëre atmoſphaerico inflavimus. Dum in

Exp$^{t.}$ 7. " The Sternum of a Dog tied down upon a table was removed, and the lungs by means of a proper pair of bellows were inflated ; whilſt air was thrown in, and the blood circulated through the pulmonary veins red and florid, the left ventricle of the heart and the arteries continued to beat with their uſual force. A proper quantity of atmoſpheric air being thrown into the lungs and there confined, the blood circulating in the pulmonary veins began to grow black, and

in eos inſpirabamus, et ſanguis, per pulmonum venas tranſiebat rubeus et floridus, ſiniſter cordis ventriculus, et arteriae, more et vi naturae ſolitis, pulſabant. Totum aëra atmoſphaericum in pulmones injectum, ibi cohibuimus: tum ſanguis, qui pulmonum venas circuibat, nigreſcere; cor et arteriae minus crebro debiliuſque micare; donec tandem, ſanguine, in pulmonum venis, jam nigro et penitus venoſo evadente, cor tardius movebatur, arteriarumque pulſus ſenſim evaneſcebant. Sed tunc, aëre incluſo exire permiſſo, inſpirationes, ope follis, redintegrabamus; et ſanguis, qui per pulmonum venas ibat, gradatim colorem floridum reſumere: cor, eadem ratione, reviviſcere; omneſque arteriae magis et magis crebro validiuſque pulſare coeperunt; donec, redeunte rubro colore, cor et arteriae, naturae ſolito more, pulſare videbantur,&c." p. 52.

and the motion of the heart and arteries became leſs frequent and powerful, till at length the blood in the pulmonary veins becoming black and like venous blood, the motion of the heart became ſtill more ſlow, and the pulſation of the arteries gradually became imperceptible. The included air being then permitted to eſcape, air again repeatedly thrown in by means of the bellows, and the blood paſſing through the pulmonary veins gradually regaining its florid colour, the heart again began to recover its power, and the arteries to beat quicker and ſtronger, till at length its red colour being reſtored to the blood, the heart and arteries ſeemed to beat with their natural force." &c.

All theſe experiments and obſervations being conſidered, it ſeems allowable to draw the following concluſions:

1ſt. That the *ſlorid red* colour of *arterial* blood, is produced by its *abſorption* of *pure air*, whilſt expoſed to the atmoſpheric air in the lungs, during reſpiration.

2nd. That the *black* colour of *venous* blood, is owing to this *pure air* being *decompoſed*, or otherwiſe *deſtroyed*, or *taken from* the arterial blood, as it circulates through, and gives ſupport to the various parts of the animal ſyſtem.

3rd. That the exiſtence of a *detached* or *ſuperabundant* phlogiſton in the blood, communicable to the air, is *doubtful*, or at *moſt* very inconſiderable.

4th. That if it does exiſt in that ſtate, it does *not* ſhew any *deleterious* or *ſedative* effects upon the heart, while in the *right* ventricle or auricle, and conſequently is *not* the cauſe of death, when it circulates in the ſame ſtate to the *left*.

5th. That the *florid* colour of the blood in the pulmonary veins, left auricle and ventricle of the heart, and in the arteries, is the only criterion by which we *might* judge, that it is in a *proper ſtate* to ſupport the phenomena of life; that this colour depends upon the preſence of *pure air*, and conſequently, that the cauſe of death, when animals are deprived of this pure air, is the *want* of a proper *ſupply* of it, to the Blood by the proceſs of animation deprived of it.

Since then the nervous fluid is of a phlogiſtic nature: pure air is abſorbed by the blood: heat is produced by the combination of phlogiſton and pure air, and this combination in animals is effected by muſcular exertion or excitation, the next thing to be explained is, how the nervous fluid by the exertion of the muſcles, is ſo combined with the pure air in the blood, as to form the heat of animals.

SECTION VI.

The manner in which Animal Heat is generated by muſcular Exertion.

IT hath been ſhewn, that no muſcle can act without an influx of nervous fluid, nor be kept in action, without a continual ſtream of that fluid through or along its fibres.

It is alſo as certainly known, that if the *artery*, or *arteries*, ſupplying a muſcle be compreſſed, or cut, ſo as to interrupt the influx of blood from the heart to the muſcle, it becomes flaccid, cold, and at length paralytic; therefore 'tis evident, that the *action* of a muſcle, and its *power* of *generating heat* in conſequence of that exertion, in a certain degree depends upon the *influx* and *circulation* of a proper quantity of *arterial blood* through its veſſels, as well as upon the influx of nervous fluid; and that if it is not duly ſupplied with both, it becomes paralytic, and loſes its power of generating heat.

It appears ſufficiently evident therefore, that animal heat is generated in the following manner.

When certain *Ideas* or *volitions* are excited in the *brain*, or when certain *feelings* or *motions* are produced there, by the actions of certain *ſtimuli* upon the extremities of the *nerves* extended to the involuntary muſcles, and by thoſe nerves communicated to the brain, it determines, impels, or tranſmits along the nerves, a proportionate quantity of the nervous fluid; this fluid paſſing along the muſcular fibres, excites them to contract; that is, increaſes the attraction, or approximation of the particles of which the muſcular fibres are compoſed, to each other.

But, from the preceding conſiderations, it appears that this attraction between the component particles of which the muſcular fibres are compoſed, is not produced by the nervous fluid becoming fixt, ſtationary, or combined with the fibres of the muſcle, but by *moving* or *paſſing along* them: therefore, after having paſſed the fibres, and excited them, it muſt paſs into the *fluids* contained within the body of the muſcle. It is evident therefore, that the nervous fluid, after having excited the muſcular fibres, muſt paſs into the *blood*, contained in its proper veſſels, every where forming ſo large a part of the bodies of the muſcles. This *nervous fluid* therefore, received into the *blood*, unites with the *Pure Air*, contained there, and forms *heat*. Perhaps it ſuffers ſome change in the mode of combination of its principles, by exciting the fibres of the muſcles, which renders its phlogiſton more detached, and ready to combine with the pure air in the blood, than it would be without paſſing along the fibres. The *Blood* thus deprived of its pure air, in the extremities of the arteries, by its union with the phlogiſton of the nervous fluid, becomes *black*, and is returned by the veins to the right auricle and ventricle of the heart, to be tranſmitted by the pulmonary arteries through the lungs, there again to receive from the atmoſpheric air, a freſh ſupply of pure air, by which it again becomes fit for the purpoſe of receiving phlogiſton from the nervous fluid, when commixt with it in the muſcles during their action; and conſequently again becomes fit, to ſupport all the functions of the living animal body, which depend upon motion and heat.

From all then that hath been advanced in the preceding part of this tractate, it appears allowable to draw the following concluſions.

1ſt. That the *Brain* ſeparates from the *Blood*, a ſubtile elaſtic *fluid*, of a *phlogiſtic* nature.

2nd. That this fluid by the *action* of the Brain, in conſequence of *volitions* ariſing, or *feelings* excited there by the action of ſtimulating matters upon the nerves and by them communicated, is *propelled* or *tranſmitted* along the nerves to the *muſcles*.

3rd. That the *Fibres* of muſcles, by the nervous fluid thus paſſing through or along them, are *excited* to *contract*, owing to the attraction between the ſolid particles of which the muſcles are compoſed, being *increaſed* by the energy of the nervous fluid paſſing through them.

4th. That the nervous fluid does not remain *fixt*, or *united* with the fibres of muſcles, but *paſſes* into the *Blood*, contained in the veſſels of the muſcles.

5th. That the *principles* of which the nervous fluid is compoſed, are ſo diſpoſed after giving excitement to muſcular fibres, that the *phlogiſton*, which forms one eſſential part of it, is capable of forming an *union* with the *pure air*, contained in the *Blood* with which the muſcles are ſupplied by the arteries.

6th. That this combination of the phlogiſton of the nervous fluid, with the pure air contained in the blood, forms *heat;* and conſequently

7th. That the *quantity* of heat generated by a living animal, muſt be *proportionate* to the quantity of nervous fluid thrown into the Blood: and *that* to the degree of muſcular exertion; and therefore

8th. That the *quantity* of muſcular exertion, and heat produced in conſequence thereof, muſt require a quantity of *pure air*, *proportionate* to the quantity of nervous fluid. Therefore it muſt follow,

9th. That the degree of *quickneſs* of the *circulation* of the *Blood*, or the *number* of *contractions* of the *heart*, muſt be *proportionate* to the quantity of nervous fluid paſſing into the Blood: to the quantity of heat generated: or to the exertion of the muſcles; and conſequently,

10th. That the more quickly the blood circulates thro' the arteries of the muſcles, and becomes deprived of its pure air as ſuch, the more quick muſt be its return to the *heart*, and *circulation* through the *Lungs;* and the more frequent muſt be the *reſpirations*, to *reſtore* to it the quantity of pure air that is loſt, by the formation of heat by its union with the phlogiſton of the nervous fluid.

The firſt ſeven concluſions appear to me to be already ſufficiently proved, and the 8th. 9th. and 10th. to ariſe naturally from them. If therefore in the next Section theſe laſt concluſions be ſhewn to be *not falſe:* it will be a proof that the *former* are *juſt*, and the *principles* from which they were drawn, *true*.

SECTION VII.

The degree of muſcular exertion being increaſed or diminiſhed, is always accompanied with a proportionate increaſe or diminution of action, in the Heart and Lungs.

ANIMAL Heat being a compound, produced by the mixture of the nervous fluid with pure air, and that combination the reſult of muſcular exertion, it muſt of neceſſity happen, that the *more* the muſcles are exerted, the *greater* muſt be the quantity of nervous fluid thrown into the blood contained in them; and conſequently the quantity of pure air neceſſary to form heat by *ſaturating*, or *combining* with that *increaſed* quantity of nervous fluid, muſt alſo be proportionately greater: therefore a greater quantity of blood muſt be required to ſupply it. But as the quantity of blood contained in the muſcles, is perhaps nearly the *ſame* during their contraction as when relaxed, the only means of increaſing the quantity ſupplied to the muſcles, in any given time, is by *quickening* or *accelerating* the motion of the blood through them.

That this accelerated motion of the Blood, ſhould *exactly* correſpond with the degree of excitement in the muſcles, 'tis neceſſary, that the motion or exertion of the *Heart*, ſhould *always* bear a *certain proportion*, to the *united* exertions of the other muſcles. — And as the quantity of pure air deſtroyed or decompoſed in the Blood, is proportionate to the quantity of nervous fluid thrown in by muſcular exertion, 'tis evident, that to *ſupply* this *loſs* of pure air to the Blood, as *faſt* as it is deſtroyed, the exertions of the Lungs, or *number* of *Reſpirations*, muſt alſo be *proportionate* to the exertions of the muſcles of the other parts of the body.

To ſatisfy myſelf of the truth of theſe concluſions, I made the following obſervations and experiments.

At the time of trying the 5th Exp$^{t.}$ Sect. 3. p. 52, I obſerved that the temperature of the air in the room was 59, the number of the pulſations of the heart were 70, and the reſpirations 18 in a minute, when I began the experiment; and as my body remained at reſt all the time of that experiment, I repeatedly found the number of pulſations and reſpirations remain'd the ſame, and ſo continued 'till I began with Expt. 6.— But ſoon after my muſcles were thrown into that ſtate of contraction, or exertion, there mentioned, I found the number of reſpirations in the minute, was augmented to 36, and of the pulſations of the heart to 101, and there continued till the experiment was finiſhed, and the muſcles were relaxed. So that to form the quantity of heat capable of raiſing one pint of water 5°. that is, from 57 to 62, by being only expoſed to that ſmall part of the ſurface of the body the hand, ſo much *pure air* had been deſtroyed in conſequence of the exertion of thoſe voluntary muſcles, as had required an addition of 18 *reſpirations* per minute, for 15 minutes, to *reſtore* it to the Blood; and to *ſupply* it *faſt enough* to combine with the nervous fluid, neceſſarily flowing into the blood, after giving this degree of excitement to the voluntary muſcles, the *heart* was excited to *contract* 31 *times* in the minute, more than was neceſſary when the *voluntary* muſcles were at reſt, and the *involuntary only* in action.

I ſoon convinced myſelf that *this increaſed* action of the heart and lungs, was not produced in conſequence of the quantity of heat generated, or any increaſed motion of the ſolids—for examining the number of reſpirations and pulſations when ſitting ſtill, I found that in a moment, by violently graſping the arms of my chair, or even ſtretching out my legs with force, the number of reſpirations and pulſations were greatly increaſed; and that always in proportion to the degree of muſcular exertion. This *increaſed action* of the heart and lungs, or muſcles ſubſervient to reſpiration, being produced at the *ſame inſtant* in which the muſcles began to be excited, muſt have ariſen from the *ſame cauſe*, that is, an *increaſed quantity* of *nervous fluid* tranſmitted to them by the Brain, *proportionate* to the quantity ſent to the other muſcles at the ſame time; and *this increaſed quantity* is tranſmitted to the *Heart and Lungs*, *ſo long* as it continues to flow to the *other* muſcles.

The Lungs and Heart therefore agree in this reſpect, that *each* receives a quantity of nervous fluid from the brain, *proportionate* to the quantity tranſmitted to *all* the other muſcles of the body; by which, their motions are ſo regulated, that the *Blood* is always ſupplied with *pure air*, in proportion to the demand for it in the ſyſtem, by the action of reſpiration; and *that* Blood is always *ſent* to the muſcles in *ſuch quantities* in any given time, by the action of the Heart, as is neceſſary to ſupply a quantity of pure air, *ſufficient* to *ſaturate* the nervous fluid flowing into it, from the excited muſcular fibres; and this ſaturated combination forms a proportionate quantity of heat.

But beſides this, it is neceſſary that the heart be poſſeſs'd of *another* property, that is of being *ſenſible to*, and *ſtimulated by heat,* and that in proportion to the *quantity of it in the ſyſtem,* whether generated there or not. For if there were no proviſion in the Animal Œconomy, for the expulſion of heat, in proportion to its generation, 'tis evident, that the heat during violent muſcular exertions, would be *accumulated* to a great degree; but it appears from the preceding obſervations and experiments, that it is *not*, but flows off from the ſurface in an increaſed quantity, therefore 'tis equally evident that there *is* ſuch a proviſion in the animal œconomy; and that heat is *never* accumulated, but when its evaporation from the ſurface is *obſtructed*, by ſpaſm, or ſome other cauſe, when the functions of the body are diſordered; and that then the accumulation of heat forms Fever, or inflammation.

The Heart muſt therefore have the property of being *ſtimulated* by heat, in a remarkable degree; and its action muſt *always* bear a proportion to the quantity of heat *in* the body; and the quantity of *blood* thrown by the heart to the *ſurface*, will therefore be proportionate to the quantity of heat it contains; and the quantity of *evaporation* or *perſpiration*, form'd by the union of that heat with the fluid part of the blood, or perſpirable matter, will again be in proportion *to that.* — That this is in reality the caſe, we need only conſider the *evident increaſe* of evaporation from the ſurface, during violent exerciſe, to be convinced. For in a temperate air, while the body remains at reſt, this evaporation is *inſenſible*: but by violent exerciſe it becomes ſo *evident*, as to run in ſtreams down the ſurface of the body, and render the ſubſtances in contact with it, evidently *wet.*

The degree of moiſture thus communicated to the air, might eaſily be determined by confining the hand in a bladder, containing a certain quantity of air, in the ſame manner as I employ'd the water, and after a certain time of reſt, and of exerciſe, examining the degree of moiſture in each caſe communicated to the air, by an Hygrometer — but not having one convenient for this purpoſe, and being fully ſatisfied of the fact from the preceding obſervations, and conſiderations, I never have tried the experiment.

However, to ſatisfy myſelf that the Heart is *ſtimulated* by heat, *independent* of muſcular exertion, in an *eminent* degree, I made the following experiment.

The temperature of the air which I inſpired, in my room, was 60°. the number of pulſations of the heart in a minute, were 63, and of reſpirations 18.

I then placed myſelf ſo *near* the Fire, that the heat communicated to my ſkin was 112°. and by holding the thermometer at the ſame *diſtance* from the fire, and of the ſame *height* with my mouth, I found the air I inſpired was alſo heated to 112 — after ſitting in this manner ſome minutes expoſed to the heat of the fire, I examined the ſtate of my pulſe, and found the number of pulſations were increaſed to 100, but the number of inſpirations were *ſcarcely* 17 in the minute—the perſpiration was now ſo *greatly* increaſed, as to become *ſenſible* under the form of ſweat. 'Tis evident therefore, that the number of the contractions of the heart were increaſed 37 in a minute, by the *ſtimulus* of heat *alone*; by which the determination of *blood to* the *ſurface*, and conſequently the evaporation of *heat from* it, were *increaſed* to preſerve the temperature of the body, as near as poſſible at its natural ſtandard.

But, tho' the heat had ſo *evidently* increaſed the frequency of the contractions of the heart, the number of reſpirations were *rather diminiſhed* than increas'd; the reaſon of which perhaps may be, that the *degree of heat* neceſſary to ſupport the animal functions, requires a continual ſupply of nervous fluid from the brain, and pure air from the blood to ſupport it, by the actions of the involuntary muſcles; but, in this caſe, a ſufficient quantity of heat was ſupplied by the fire to ſupport thoſe actions, whereby a leſs expence of pure air became neceſſary, and fewer reſpirations,

reſpirations were required to ſupply the loſs. But be that as it may, 'tis evident that the number of *reſpirations*, is always *proportionate* to the quantity of pure air deſtroy'd in the blood, by the generation of heat, and conſequently to the *degree* of muſcular exertion in the ſyſtem; while the number of *contractions* of the *heart* depends upon the *degree* of muſcular exertion, and the *quantity* of heat *alſo* preſent in the body.

For in the preceding experiment, the heat independant of motion, had increaſed the contractions of the *heart* from 63 to 100, becauſe it is ſtimulated by heat; but the *Lungs* are *not* ſtimulated by heat, and there was no *increaſed muſcular action* to diminiſh the quantity of pure air in the blood; therefore there was no neceſſity for any increaſe in the number of reſpirations. But had the number of pulſations of the heart been increaſed to 100 by *exerciſe*, the expence of pure air in conſequence of that muſcular exertion, *muſt* have required a *quicker reſpiration* to have ſupplied the loſs; to convince myſelf of which, I threw my muſcles into ſtrong action, 'till the number of pulſations were 100 per minute, as in the former caſe; when I found the number of *reſpirations* was *increaſed to* 25——tho' when the pulſations were increaſed to the *ſame number* by *heat*, the *number* of *reſpirations* was *only* 17.

From theſe conſiderations, it appears then that the concluſions in the laſt chapter, are *true*; and the principles from whence they were drawn, are further confirm'd thereby. The ſame obſervations likewiſe point out theſe following *invariable Laws* of the Animal Œconomy.

1ſt. That whatever be the quantity of nervous excitement, energy, or *fluid*, ſent from the brain to the other muſcles voluntary, or involuntary, a quantity always bearing the *ſame* proportion, is ſent at the *ſame* time to the Lungs, or muſcles ſubſervient to reſpiration; by which means, the quantity of pure air communicated to the Blood in the lungs, is always proportionate to the quantity deſtroy'd by forming heat with the phlogiſton of the nervous fluid, united with it in conſequence of muſcular exertion. For if the quantity of nervous fluid ſent to the reſpiratory muſcles, be in the *ſame* proportion with that ſent to all the other muſcles: 'tis evident, that the degree of their action, will alſo at all times bear the *ſame* *ratio*, to the quantity of the *united actions* of *all* the other muſcles.—Therefore the more the muſcles are exerted, the more quick will be the reſpirations—and vice verſa.

2nd. That the quantity of nervous fluid ſent to the *Heart* alſo, bears always the *ſame* proportion to the quantity ſent to all the other muſcles; therefore the degree of exertion of the other muſcles, is always accompanied with an *equal* degree of action of the *heart*; by which means, the quantity of *arterial* blood, and conſequently of *pure air* ſent by the *Heart* to a muſcle, or muſcles, in any given time, is always proportionate to the quantity of muſcular *exertion*, and *nervous fluid* evolv'd by that exertion.

3rd. That the *Heart* is peculiarly *ſenſible* to the action of *heat*—that the quantity of heat in the Body, always produces a correſpondent degree of action of the *heart;* by this means, the quantity of *blood* thrown *to*, and *heat* evaporated *from* the ſurface, is always in a healthy animal *proportionate* to the quantity of heat *in* the *ſyſtem*—and by this property of the heart, the even, natural temperature of the animal body, is conſtantly preſerved; and

4th. That the action, or number of contractions of the heart, are always in a *compound ratio* to the degree of muſcular exertion; and to the quantity of heat preſent in the ſyſtem.

And now perhaps it will not be improper to give one general, comprehenſive, or Synoptical View of the whole, and then conclude the ſubject.

1. Whilſt an animal body retains the *living principle*, its moving ſolids, or muſcular fibres poſſeſs *excitability*.

2. So long as an animal is capable of *excitement*, ſo long can it *generate heat*, but no longer.

3. *Excitability* of the muſcular fibres, is the great characteriſtic of *Life* in animals.

4. *Excitation*, or muſcular *exertion*, is the efficient *cauſe* of animal *heat*.

5. *Food* and *Air* are *both* eſſentially neceſſary to the ſupport of animal *life*, and animal *heat*.

6. *Food* by digeſtion &c. ſupplies Chyle to the *Blood*, and from that a *phlogiſtic fluid* is ſecreted by the Brain.

7. Atmoſpheric *Air* during reſpiration, ſupplies the blood with *Pure Air*, which being abſorbed, changes the black colour of the blood to a florid red.

8. The nervous *fluid* ſecreted from the blood by the *Brain*, is propelled by it along the nerves whenever the Brain is excited, to the *muſcles*; where by its *influx* and *motion*, it excites them to action, or exertion.

9. The quantity of Blood ſent to the muſcles in any given time, is proportionate to the quantity of *nervous fluid* ſent to them; and conſequently

10. The quantity of *Pure Air* alſo ſent to the muſcles, is always proportionate to the quantity of *nervous fluid*.

11. The quantity of *heat* generated, is always proportionate to the degree of *muſcular exertion*: that to the quantity of *nervous fluid* ſent to the muſcles;

muſcles: and that again to the quantity of *pure air* ſent to them.

12. The nervous fluid and pure air ſent to the muſcles, by exciting them *loſe* all their diſtinguiſhing properties, and can be no longer found in their original forms; but

13. At the ſame time that the nervous fluid and pure are commixt in the blood, during muſcular exertion, and *loſt* as ſuch, the quantity of *heat* in the blood is *increaſed*; therefore

14. The *Heat* generated by animals in conſequence of muſcular exertion, is formed, by a *combination* of the *nervous fluid*, with the *pure air* contained in the Blood; and conſequently

15. The quantity of nervous fluid and pure air deſtroy'd as ſuch, by their union, muſt produce a proportionate quantity of *heat*; therefore

16. The *heat* produced is always proportionate to the *muſcular exertion*, by which the nervous fluid is ſupplied; and

17. The *action* of the heart is always proportionate to the *exertion* of the *other* muſcles; by which action a proportionate quantity of pure air, is ſupplied to unite with the nervous *fluid*, to form this heat; and

18. The number of reſpirations, or degree of action of the muſcles ſerving to move the *Lungs*, muſt bear the *ſame* proportion to the exertion of the other muſcles, that *pure air* may be ſupplied to the Blood in the Lungs, as faſt as it decompoſed in the *muſcles*.

19. The Heart is very *ſenſible* to the ſtimulus of *heat*, and its motion always bears a *proportion* to the *quantity* of it preſent in the ſyſtem; as well as to the degree of *muſcular exertion*; by which means, the quantity of heat ſent *to*, and evaporated *from* the *ſurface*, is always proportionate to the quantity preſent *in* the *body*. And to theſe we may add the following obſervation, as the 20th.

20. That as the quantity of *nervous fluid* ſent to the Heart, and muſcles of reſpiration, is always

proportionate to the quantity ſent to *all* the *other muſcles;* and conſequently *their actions* proportionate to the *exertion* or *excitement* of the *Brain;* 'tis evident, that the quantity of *pure arterial blood* ſent *to* the *Brain,* to ſupport *its* functions, and ſupply *it* with *materials* whereof to form the nervous fluid, is always proportionate to the quantity of *nervous fluid* ſent *from* it, to ſupport the animal functions of *every other part* of the *ſyſtem.* For as the *Brain* always ſends a quantity of *nervous fluid* to the heart. proportionate to the degree of excitement: the *heart* muſt always ſend to the brain a quantity of *arterial blood,* proportionate to that excitement, in conſequence of its action being always proportionate to the excitement it receives.

And the quantity of *pure air* ſent to the brain, muſt always be proportionate to the *excitement* of the brain, becauſe the quantity of *arterial blood* is ſo; which arterial blood always contains a *certain proportion* of pure air; becauſe the quantity of it expoſed to the action of atmoſpheric air in the Lungs, is always proportionate to the quantity of pure air decompoſed by the nervous fluid in the muſcles; on account of the quantity of energy, or nervous fluid, tranſmitted to the lungs to excite their action, by which pure air is abſorbed, being *always proportionate* to the quantity ſent to the other muſcles, by which *that pure air* in the blood is decompoſed, to form *animal heat*.

And now, having brought my ſubject to a concluſion, I can only add, that upon an impartial review, *each part* ſeems to be conſiſtent with *every other*, and the *whole* with what *every one* may *obſerve*, *invariably* to take place within himſelf.

If I walk ſlowly along, for the ſpace of one hundred yards upon even ground, my breathing and pulſe are but little accelerated, and the heat of my body remains nearly the ſame as before. But if I walk at the *ſame ſpeed*, up a *ſteep hill*, or *bearing* a *heavy burthen*, for the *ſame diſtance*, my breathing becomes *full* and *frequent*: my heart beats *ſtrongly* and *quick*: and the quantity of heat thrown off from the ſurface of my body, is ſo *greatly increaſed*, that the perſpirable fluid with which it unites and evaporates, cannot be taken up by the air in contact with my body, *ſo faſt* as it is thrown off; therefore it is condenſed, and runs in ſtreams down the ſurface.

What is the cauſe of this *difference*, when the *ſpace*, the *ſpeed*, and the *actual motion* of the muſcles are the *ſame?* Certainly the *quantity* of *muſcular exertion*, or *nervous energy* tranſmitted from the brain to the muſcles in the *latter* caſe, where the body was *raiſed* on high, or where a *weight* was carried, being *much greater* than when the body was *only moved*, without being lifted up, or without any additional weight upon it.

For though the *motion* of the muſcles was the *ſame* in both, yet the *increaſed* weight to be moved, required the muſcular *power* or *exertion* to be much greater in the latter caſe than in the former; and that exertion was produced, by the *volition* or *determination* of the *Mind*, propelling a *greater* quantity of Nervous Energy, or fluid, from the brain to the muſcles employed; therefore to the increaſed quantity *alone* of nervous fluid, tranſmitted from the brain to the muſcles, to give them the neceſſary increaſe of power, are the *accelerated pulſations* and *reſpirations*, and *increaſed* production and evaporation of *heat*, to be attributed.

And indeed how could it be otherwiſe? The mind or brain *cannot* throw a *diſtant* muſcle into action, without tranſmitting *ſome power*, *energy*, or *fluid to* it, to increaſe the attraction or approximation of its parts. This fluid of the Brain after exciting the muſcles, being *ſomething*, muſt paſs *ſomewhere*, and have *ſome effects*; therefore it paſſes into the *blood*, where meeting with *pure air*, it forms *heat*. But, as the quantity of nervous fluid thrown into the blood, depends upon the degree of exertion of the muſcles, it is neceſſary, that the quantity of pure air taken into the blood in the lungs, and the quantity of that blood propelled by the heart through the muſcles, ſhould *always* be *proportionate* to *that* quantity of *nervous fluid*, that it may be *ſaturated*, and form a proportionate quantity of *heat*; for which purpoſe, that *grand Law* of the Animal Œconomy was inſtituted, that the quantity of nervous fluid ſent from the brain *to*, or degree of action excited *in* the *Heart* and *Lungs*, ſhould always be proportionate to the quantity of nervous fluid ſent *to*, and degree of exertion *of all* the *other muſcles*. And the *Heart* is alſo endowed with a *ſenſibility* to the action of *heat*, that it may tranſmit to the ſurface a quantity of *blood*, proportionate to the quantity of *heat* in the ſyſtem, that the *redundant heat* may be thrown off, and the *body preſerved* at its *natural temperature*.

APPENDIX.

In which the Chemical Effects, produced by the Nervous Fluid uniting with Pure Air in the Blood, are more particularly conſider'd.

IN conſequence of what hath been advanced in the preceding parts of this treatiſe, I will ſuppoſe it granted me, that the nervous fluid determined to a muſcle by the brain, produces a contraction of its fibres; and afterwards paſſing into the Blood contained in the muſcle, and meeting there with the pure air abſorb'd during the paſſage of the blood through the lungs, the phlogiſton of the nervous fluid unites with ſome part of the pure air, and forms *that heat*, which is the immediate object of this enquiry.

In the *Introduction* to this diſſertation, I gave a general explanation of what I ſuppoſe to be the Elemental Principles of Nature, and conſequently of Chemiſtry. I mentioned *Æther* and *Phlogiſton* as the two grand *active*, and an *Acid* and *Earth* as the two *more paſſive* principles. Likewiſe, that the only immediate attractions, are 1ſt. between Æther and Phlogiſton forming Light, Fire, or the Electric Fluid, according to the quantity of each entering the compoſition; or mode of their combination;

2ly. between Æther and Acid, forming Pure Air,

3ly. Phlogiſton and Earth, forming metals, &c. and

4ly. between Acid and Earth, forming ſaline ſubſtances.

It was intimated alſo, that Æther was the grand, or general Cauſe of Elaſticity and fluidity; and Phlogiſton, of fixity and ſolidity.

If from theſe principles, a conjecture may be hazarded concerning the *compoſition* of the nervous fluid, I ſhould ſuppoſe, that it contains Phlogiſton with an *Earthy baſe*, but intimately combin'd with a certain proportion of Æther. — Its mobility and fluidity, point out the preſence of Æther: its phlogiſtic nature hath been inveſtigated already, partly from the materials of which it is form'd, and partly from the effects it produces;

duces; and as the quantity of phlogiſton, which it muſt contain to produce the effects it does, muſt be very conſiderable, and moſt probably in much greater proportion than the Æther: and as it is different from Light, Fire, and Electricity, it muſt have ſome *baſe* to give it its degree of fixity; conſequently, as Phlogiſton hath an attraction to *Earth*, but none to Acid, it is moſt natural to ſuppoſe, that *this baſe* is an *Earth.* The Earth attracts the phlogiſton, ſo as to give it a degree of fixity: while the Phlogiſton having an affinity both with the Earth and Æther, hath its attraction ſo divided, that its intimate combination with either is prevented, and a certain degree of elaſticity and fluidity is preſerved.

The nervous fluid ſecreted from the blood by the brain, then is ſupplied with Phlogiſton and Earth, by the aliments taken in as food; and it ſeems to acquire its Æther from the blood; a great quantity of *which* is ſent to the Brain by the heart, immediately after it hath been impregnated with pure air, (containing Æther) in the Lungs. And the quantity of blood carried by the carotid-arteries to the Brain, ſaturated with pure air, and returned by the Jugular Veins, deprived of it, altho' there is no great muſcular exertion carried on there, ſeems to confirm the idea.

These conjectures, making the principles of which the nervous fluid is compoſed, the *ſame* as thoſe forming Light, Fire, and the Electric fluid, *excepting* the ſmall quantity of *Earth* contained in the nervous fluid, ſeem to acquire a degree of probability from conſidering the *Torpedo*, which hath the power of giving a *ſhock*, *ſimilar* to that of Electricity, by the nervous fluid tranſmitted in conſequence of volition. But in the Torpedo, the nervous fluid ſeems to contain a *greater* proportion of Æther, than of Phlogiſton; and if ſo, perhaps the baſe is Acid, or the mode of combination between the Æther and Phlogiſton, is ſome how different from what it is in other animals, not poſſeſt of that peculiar property, or power.

Suppoſing therefore that the *nervous fluid* conſiſts of an Earth, united to much Phlogiſton, along with a certain *ſmaller* quantity of Æther; the next thing to be conſider'd, is the effects that muſt enſue, from its *meeting* with the *pure air* in the blood.

The nervous fluid then conſiſts chiefly of an Earth and Phlogiſton; the pure air of an Acid and Æther; conſequently a double attraction and decompoſition muſt take place, and two new compounds ariſe; for the Earth of the nervous fluid, will unite with the Acid of the Air: while the Æther of the Air combining with the Phlogiſton of the nervous fluid, will form heat.

But the quantity of the phlogiſton contained in the nervous fluid, being in an *over proportion*; the æther of the pure air combines with a *ſufficient* quantity of it, to form heat, and leaves its acid diſengaged; while the *redundant* part of the phlogiſton, remains ſtill united with the earthy baſe of the nervous fluid. This phlogiſticated Earth therefore, will combine with the diſengaged acid of the pure air, in a certain proportion, and take along with it a part of the Æther, with which it was originally combined, and form *Volatile Alkali*. This volatile alkali therefore is produced, from the intimate union of the *Earth*, *Phlogiſton*, and *Æther* of the nervous fluid, with as much of the diſengaged *Acid* baſe of the pure air, as the Earth and Æther could attract; their quantity of attraction being neceſſarily diminiſhed by the portion of phlogiſton already combined with them.

The whole of the nervous fluid therefore is now diſpoſed of: part of its phlogiſton forming heat, with the æther of the pure air; and the other part of the phlogiſton remaining united with the Earthy baſe, and Æther entering into its original compoſition, combining with ſo much of the diſengaged acid of the pure air, as they can *intimately* unite with. For the Earth and Æther of the nervous fluid, being deprived of a great part of their phlogiſton by the formation of heat, will eagerly attract any thing they can meet with of a phlogiſtic, or acid nature, to ſupply its place; meeting therefore with the diſengaged acid of the pure air, to which both the Æther and Earth have ſo ſtrong an affinity, they ſeize upon it, and ſaturate themſelves with ſo much as they can take into an intimate combination; and this compound, is diſtinguiſhed by the name of *Volatile Alkali.*

We have then volatile alkali, and the remaining part of the diſengaged acid, left. But, tho' the Earth and Æther, could not *intimately* combine with a greater quantity of Acid, yet in this *compound* ſtate, they retain a *leſs* intimate degree of attraction for it; and although that degree is far leſs, than what they have for that portion of Acid eſſential to the exiſtence of the compound, yet it is *greater* than for moſt other ſubſtances; therefore, this alkali and acid will unite and form an *Ammoniacal ſalt.*

But, from the circumſtances to which this acid is expoſed, during its ſeparation from the Æther with which it was combined, and to which it hath ſo ſtrong an attraction, a ſmall portion of *Æther* is retained; and perhaps by means of that Æther, a minute portion of *Phlogiſton alſo;* and and theſe ſmall additions, are ſufficient to give it properties *different* from thoſe of pure acid, and of every acid produced under different circumſtances, and conſequently retaining theſe additional principles in different quantities and proportions; therefore this Acid thus produced, is of a *peculiar* nature; and is known to Chemiſts, by the name of *Phoſphoric Acid*; and conſequently, the neutral formed by its union with the Volatile Alkali, will be a *Phoſphoric* ammoniac.

But, whether the baſe of the nervous fluid be an Earth or not, I am fully convinced in my own mind, that volatile alkali is compoſed of thoſe principles, which I have hinted at; and likewiſe, that it is generated, or produced, by the mixture of the nervous fluid with pure air, in the blood, in conſequence of muſcular exertion. If therefore, the Earth be not ſupplied by the nervous fluid, the reſiduum of the phlogiſton of the nervous fluid (after ſaturating the Æther of the pure air, and paſſing off in the form of heat,) meets with *this Earth* in the *blood*, and ſuperphlogiſticates it; and in that ſtate enters into an intimate union, with ſo much of the diſengaged Acid of the pure air, as enables it to take the form of Volatile Alkali. But from what hath been ſaid, and from other conſiderations, not immediately connected with my preſent ſubject, therefore not mentioned, I am inclined to adopt the *former* opinion, that the Earth is ſupplied by the *nervous fluid*.

'Tis likewiſe not very material at preſent, to determine whether the portion of Æther neceſſary to form Volatile Alkali, be ſupplied by *that* entering into the original compoſition of the nervous fluid, and perhaps ſtill combined with the earth and remaining phlogiſton; or by a ſmall quantity, obſtinately retained by the acid of the Pure Air, to which it has ſo great an affinity, as not to be eaſily inſtantly ſeparated; or by both.

This opinion, concerning the nature and compoſition of Volatile Alkali, and its production by the Animal proceſs, ſeems to be confirmed by the Chemical productions of it. For when a quantity of Earth, hath an opportunity of combining with a *large* proportion of Phlogiſton, with the interpoſition of a *ſmall* portion of Acid, and Æther, the reſult is volatile alkali; for inſtance, Dr. Prieſtley * found, that Iron expoſed to Nitrous Air, gave evident ſigns of the production of Volatile Alkali. In this caſe the Iron furniſhes Earth, and a quantity of Phlogiſton; while the Nitrous Air, conſiſting of Acid, Æther, and Phlogiſton, gives the proper quantity of Acid and Æther, and ſupplies a ſufficient quantity of Phlogiſton,

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* Prieſtley's Experiments and Obſervations. Vol. 3. p. 203.

giſton, to complete the proportions, and form Volatile Alkali, or Alkaline Air.

From this account of the compoſition of Volatile Alkali and Alkaline Air, it appears that this Air is formed of the *ſame* principles, nearly in the *ſame* proportions and mode of combination, as Inflammable Air is; for in the Introduction p. 26, Inflammable Air is ſaid to conſiſt chiefly of an Earthy baſe, united to much Phlogiſton, with a certain proportion of Æther to give it Elaſticity, and perhaps a ſmall portion of Acid. And I am of opinion that both accounts are juſt, and perhaps the chief difference between the two Airs is, that Alkaline Air, or volatile alkali in the form of Air, contains a greater proportion of Earth, and more Æther, than inflammable Air does. And this opinion, of the *ſimilarity* of the principles and mode of combination of theſe two Airs, explain, and are greatly confirmed by Dr. Prieſtley's experiments, * when by means of the Electric ſpark, or by heating bits of dry crucibles &c. in it, Alkaline Air was expanded to twice or thrice its original bulk, and become inflammable Air; for both by the action of the Electric fluid, and heat, its component principles were to a certain degree ſeparated, and the Earth had an opportunity of acquiring more phlogiſton; but that phlogiſton being attracted by the Æther, as well as the Earth of the Alkaline Air, could not intimately combine with either; therefore, the phlogiſton divided its attraction between the two; and the Earth and Æther having no affinity, were *by it ſeparated* from each other; conſequently the *bulk* of the air muſt have been increaſed, and that acquiſition of *Phlogiſton* rendered the whole Inflammable; the proportions of the principles, being then the ſame as in Inflammable Air; unleſs there might have been ſome *little* difference, in the proportions of the Acid principle, contained in the two airs.

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* Experiments and Obſervations. Vol. 3. p. 197.

A general *Chemical* View of the *whole*, therefore may be given in a few words.

The nervous fluid is compoſed of an *Earth*, united with *much Phlogiſton*, and a quantity of *Æther*,

Æther, ſufficient to give the due degree of Elaſticity and mobility.

The pure air contained in the blood, conſiſts of *Æther* and the *Acid Principle.*

When a muſcle is excited, a quantity of the nervous fluid paſſes along its fibres, and is afterwards received into the blood ſupplied from the heart, and contained in the arteries of that muſcle; which blood is ſaturated, with the pure air imbib'd during its paſſage through the lungs.

A quantity of this phlogiſton of the nervous fluid, unites with the Æther of the Pure Air, ſufficient to ſaturate it, and form that heat, which is called *Animal heat:* and the acid now diſengaged, ſtill retains a ſmall portion of Æther, and perhaps acquires a ſmall quantity of Phlogiſton, by which it becomes poſſeſt of peculiar properties, different from pure acid, and from every other Acid, produced under different circumſtances, and containing Æther and Phlogiſton in different proportions; and to this peculiar acid, Chemiſts give the name of *Phoſphoric Acid.*

At the ſame time, the *Earth* of the nervous fluid being deprived of a great part of its phlogiſton, but ſtill retaining a conſiderable proportion, with all or part of the Æther entering into its original compoſition, acquires new properties; and the attraction it exerted upon the phlogiſton, now taken from it, is transferred to a portion of the diſengaged *acid* of the pure air; with which it forms an intimate union, and acquires thoſe peculiar properties, which are diſtinguiſhed by the name of *Volatile Alkali.*

This Volatile Alkali, formed by the intimate union of Earth and Phlogiſton, with a ſmall proportion of Æther and Acid; as a *compound* hath ſtill a general attraction to the Acid: with which it now unites, and forms a ſalt, diſtinguiſhed by the name of *Phoſphoric Ammoniac.*

Thus I account for the production of *Heat*, *Phoſphoric Acid*, and *Volatile Alkali*, by the *Animal Proceſs.* Many other little circumſtances may ariſe, during this combination of the nervous fluid with pure air, which may give origin to *other* productions at the ſame time; but thoſe being of leſſer moment, at this time are paſſed over unnoticed; my preſent intention being, only to give a *general view*, of the principles I have been led to adopt, and their application to the explanation, of the *more evident* productions of the Animal Syſtem.

FINIS.

ERRATA.

Page 16, bottom line read confuſedly.
—— 17, line 2, dele . after principles.
—— 39, line 3, from the bottom read 5ly.
—— 43, l. 8, dele of the
—— 58, l. 13, read ſcene.
—— 93, l. 9, after pure, add Air.
—— 95, l. 12, after heart for . put ,
—— 103, l. 6, for Electricity, read the Electric fluid.
—— 109, l. 6, dele inſtantly.